Ontario

FLUE-CURED TOBACCO PRODUCTION

Recommendations

Publication 298

MINISTRY OF AGRICULTURE AND FOOD

Recycle old editions of this publication. Each year the appropriate working group of the Ontario Pest Management Research and Services Committee reviews the pesticides listed in this publication. To the best knowledge of the committee, at the time of printing, all of these pesticides were:

- federally registered
- reviewed by the Ontario Pesticides Advisory Committee (OPAC)
- classified by the Ministry of the Environment as of June 2003.

The information in this publication is general information only. By printing this publication, the Ministry of Agriculture and Food does not offer any warranty or guarantee, nor does it assume any liability for any crop loss, animal loss, health, safety or environmental hazard caused by the use of a pesticide mentioned in this publication.

The pesticide product label is a legal document. It is against the law to use the product in any other way. You must also use all pesticides in accordance with the *Pesticides Act* and Regulation 914, administered by the Ontario Ministry of the Environment.

In this publication, most recommendations list several pesticides that can be used for each pest discussed. In general the least hazardous materials and those pesticides that pesticide applicators have used satisfactorily for years are listed first. More toxic pesticides and/or newer ones with less practical grower experience follow.

This publication lists a number of brand names of pesticides. This is for your convenience only. It is neither an endorsement of the product nor a suggestion that similar products are ineffective.

Consult each product label for specific information such as compatibility with other materials and the effect of environmental conditions. Weather and other factors influence the effectiveness of pesticides and the likelihood of crop injury.

Health Canada has established maximum residue limits (MRLs) for pesticides. Processors or retailers may demand more restrictive limits. Growers should seek advice of their intended market as to which restrictions or limitations apply. Keep accurate and up-to-date records on pesticide use in each crop.

Federal Registration of Pesticide Products

The Pest Management Regulatory Agency (PMRA) of Health Canada grants registration following an evaluation of scientific data to ensure that the product has merit and value; and the human health and environmental risks associated with its proposed use are acceptable.

1. **Full Registration**
   Pesticide registrations are normally granted for a period of five years, subject to renewal.
2. **Temporary Registration**
   Temporary registration may be granted for a period not to exceed one year, where the registrant agrees to produce additional scientific or technical information, or the pesticide is used for emergency control of a serious pest outbreak.

Supplemental Labels

You MUST obtain a supplemental label and follow all the label directions when PMRA approves new uses for a registered pesticide that do not appear on the current label.

Examples of when you must use a supplemental label include:

- **Temporary Registrations for Emergency Use**
- **Minor Use Label Expansion** (new label statements for crops that do not already appear on that product label).

You can obtain a copy of a supplemental label from the pesticide manufacturer or pesticide vendor, the grower association that sponsored the emergency registration or minor use, from OMAF or PMRA's Pest Management Information Service.

For more information on the federal registration status check the PMRA Web site at *www.hc-sc.gc.ca/pmra-arla* or call **1-800-267-6315.**

Regulation of Pesticides in Ontario

Classification of Pesticides into "Schedules"

The Ministry of the Environment classifies all pesticide products into one of six schedules, based on the potential hazards that product may have for human health and the environment. For up-to-date information on the regulatory status of any pesticide check the Ontario Pesticides Advisory Committee Web site at *www.opac.gov.on.ca* or call (416) 314-9230/ fax (416) 314-9237.

Licensing and Certification Requirements for Pesticide Users

You must be a certified grower or licensed exterminator to buy and use Schedule 1, 2 and 5 pesticides.

Requirements for Growers and their Assistants

Growers must be certified through the **Grower Pesticide Safety Course** to buy and use Schedules 1, 2 or 5 pesticides on land they farm. There must be at least one certified grower for each farm operation.

All agricultural assistants must also receive formal pesticide safety training, recognized by the Ministry of the Environment, before they can use Schedule 2 or 5 pesticides under the supervision of a certified grower. This applies to all assistants — including family members, farm employees and seasonal workers.

For more information about training for growers and agricultural assistants check the Ontario Pesticide Education Program Web site at *www.ridgetownc.uoguelph.ca/opep/* or call 1-800-652-8573.

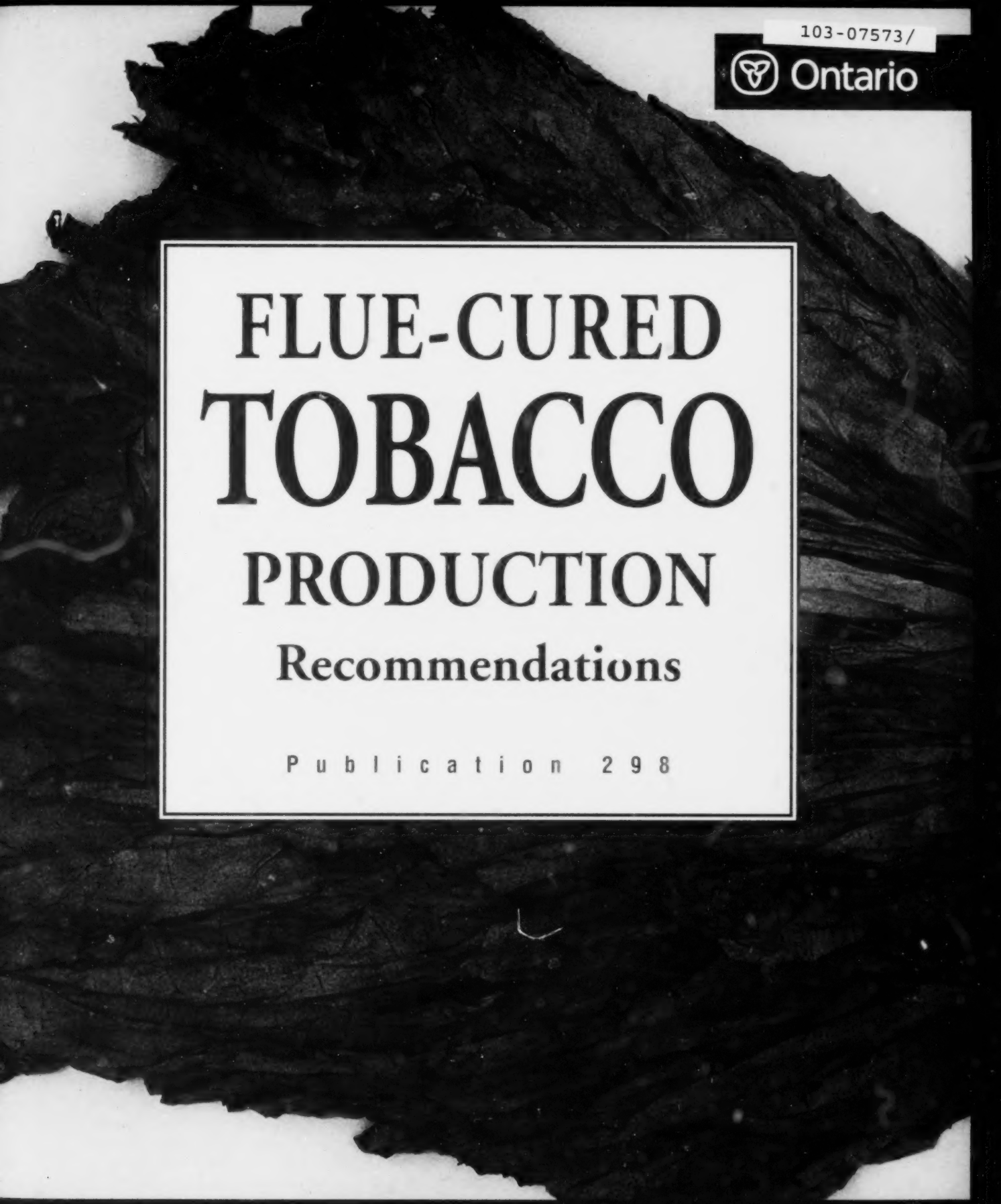
Requirements for Commercial Applicators and their Assistants

If you plan to apply pesticides as a business, you must be a licensed exterminator. **This includes farmers who custom apply pesticides for other farmers and charge a fee for this service.** You must complete a home study course and certification exam, and send proof of certification to the Ministry of Environment to obtain your license.

Unlicensed assistants must be Technicians before they may handle Schedule 2 (with restrictions), 3, 4 and 6 products under indirect supervision of a licensed exterminator. Technicians may not handle Schedule 1 and 5 products. For more information about exterminators and technicians check the Ontario Pesticide Training and Certification Web site at *www.ridgetownc.uoguelph.ca/optc* or call 1-888-620-9999.

103-07573/

Ontario



FLUE-CURED TOBACCO PRODUCTION

Recommendations

Publication 298

MINISTRY OF AGRICULTURE AND FOOD

Publication 298
Flue-Cured Tobacco Production Recommendations

Acknowledgements

The recommendations in this publication were prepared in consultation with the following committees:

Ontario Pest Management Research and Services Committee
Ontario Soil Management Research and Services Committee
Ontario Field Crops Research and Services Committee
Ontario Weed Committee

Notes:

1. Any changes in recommendations will be publicized through newsletters and other media.
2. Recommendations in this publication refer to flue-cured tobacco unless otherwise indicated.

Agriphone Services

Phone the OMAF Tobacco Agriphone Hotline. It's updated biweekly during the growing season and weekly during the rest of the year. For a recorded message, call (519) 582-1713 or toll-free at 1-800-810-0167.

Visit the OMAF web site at www.omaf.gov.on.ca to:

- view the OMAF tobacco agriphone
- subscribe online for email notifications for new agriphone postings
- find information on tobacco production and other relevant topics.

Nutrient Management Act information

The *Nutrient Management Act* received Royal Assent on June 27, 2002. Regulations are being drafted. For the most up-to-date information on this legislation, refer to the OMAF web site at www.omaf.gov.on.ca or phone the Agricultural Information Contact Centre at 1-877-424-1300.

Need technical and business information?

Contact the Agricultural Information Contact Centre at
1-877-424-1300
or
ag.info@omaf.gov.on.ca

Contents

1. Precautions with Pesticides

Pesticide regulations 1
Pesticide schedules in Ontario 1
Certification and training requirements 1
Pesticide certification for Ontario farmers 1
Training for agricultural assistants using Schedule 2 or 5 pesticides 1
Certification and licensing for commercial exterminators 2
Training for technicians working as assistants to licensed exterminators 2
General precautions 2
Protect yourself when you use pesticides 2
Protect other people, livestock, pets, water and sensitive crops 3
Read and follow pesticide label information 3
Know the hazard symbols and words 3
Re-entry periods 3
Days to harvest (preharvest) intervals, pregazing and feeding intervals 4
Crop rotation 4
Total number of applications 4
Buffer zones 4
Human health 4
Risks of pesticide use 4
Cholinesterase blood tests 4
First aid 5
Protective clothing and equipment 6
Choose and wear the appropriate protective clothing and equipment 6
Use organic vapour tractor cab cartridges 7
Safety supply companies 7
Care of protective clothing and equipment 8
How to wash your spraying clothes 8
Personal hygiene 8
Protect the environment 9
Protect water sources 9
Reduce and manage pesticide spray drift 9
Prevent bee poisoning 9
Disposal of pesticides and empty containers 10
Triple or jet rinse your empty containers 10
How to dispose of empty, triple rinsed containers 10
Unwanted pesticides 11
Surplus spray mix 11
Soluble packaging options 12
Storing pesticides 12
Pesticide spills 12
Application procedures 13
Sprayers 13
General precautions and requirements for fumigants (gases, vapours and fumes/smokes) 13
Band spraying 13
Seed treatments 14
Application by plane or helicopter 14
Conversion factor for herbicides 16
Interval before rainfall for post-emergent herbicides 16

2. Soil Management and Fertilizer Use

The *Fertilizers Act* 18
Standards for fertilizers used on tobacco 18
Soil testing 18
Soil sampling 19
Other methods of assessing nutrient needs 20
Field fertilization 20
Nitrogen 20
Phosphate and potash 20
Magnesium 21
Calcium 21
Fertilizer application 21
Leaching 21
Fertilizer placement 22
Planting water fertilizers 22
Foliage feeding 22
Manure 22
Rotations 23
Plant analysis 24
Micronutrients 25
Testing for micronutrients 25
Preventing and correcting manganese deficiency 26
Preventing and correcting zinc deficiency 26
Copper 26
Boron 26
Iron and molybdenum 26
Soil acidity and liming 26
The buffer pH 26
Limestone quality 28
The Agricultural Index 28
Limestone materials 28
Tillage depth 28
Lowering soil pH 28
Calibrating tobacco fertilizer applicators 29
Fertilizer materials 29
Water quality 30
Bacterial contamination 30
Soil erosion 30
Nitrate contamination 31
Pesticide contamination 31
Fuel contamination 31

Nutrient Management Act information 31
OMAF resources 31

3. Recommended Varieties
AC Cheng 32
AC Gayed 32
AC White 32
CT 144 32
CT157 33
CT 166 33
CT 572 33
CT 681 33
Delfield 33
Delgold 33
Delliot 33
RG 17 34
RG 81 34

4. Seedling Production
Cultural practices 36
Growth medium 36
Seeding rates 36
Time of seeding 36
Heating 37
Precision seeding 37
Plug tray seeding 38
Using vermiculite 38
Muck bed cover 38
Hardening-off 38
Fertilization 39
Testing greenhouse media 39
Testing float water 39
Fertilization before seeding 40
Fertilization during May 40
Soluble salts 40
Disease control 41
Muck bed sterilization 41
Treating walls, walks and boards 42
Plug tray sterilization 42
Damping-off (bed rot) 42
Black root rot 43
Blue Mold 43
Yellow patch 43
2,4-D injury 44
Atrazine damage 44
Insect control 44
Cutworms 44
Harvester ants 44

5. Weed Management
Adjuvants 45
Agral 90 45
AG-Surf 45
Companion 45
Dazomet 45
Enhance 46
Fluazifop-p-butyl 46
Frigate 46
Fumigants 47
Glyphosate TMS 47
Glyphosate 47
Metam sodium 47
Methyl isothiocyanate/ Dichloropropene 48
Methyl isothiocyanate/Dichloropropene/ Chloropicrin 48
Napropamide 48
Surfactants 49

6. Field Production
Cultural practices 50
Time of planting and plant population 50
Irrigation 50
Topping 51
Sucker control 52
Disease control 52
Field stunting of tobacco: nematodes and black root rot 52
Sore shin 53
Weather fleck 53
Frenching 54
Blue Mold 54
Viral diseases 56
Tobacco mosaic 56
Tobacco veinal necrosis 56
Other viral diseases 56
Insect control 56
Cutworms 56
Wireworms 57
Seed maggots 58
Tarnished plant bugs 58
Hornworms 58
Aphids 58
Flea beetles 59

7. Harvesting
Mechanical harvesters 60

8. Curing
Curing disorders 61
Green fixation 61
Browning 61
Sponge 61
Splotching 62
Scorch 62
Small spots 62
Runback 62
Disease control 62
Fungal pole rot 62
Aspergillus 63
Bacterial soft rot 63

9. Storage 65

Appendices
A: OMAF Advisory Staff 67
B: MOE Pesticides Control Offices 69
C: Agriphones and other contacts 69
D: Diagnostic service 71
E: Crop insurance 73
F: The Metric System 74

Tables

1-1. Pesticides that affect cholinesterase levels in blood 5
1-2. Safety supply companies in Ontario 7
1-3. Relative toxicity of insecticides to honeybees .. 10
1-4. *Pesticides Act* storage requirements 12
1-5. Pesticides used in producing flue-cured tobacco 14

2-1. OMAF-accredited soil tests 19
2-2. Accredited soil test labs in Ontario 19
2-3. Phosphate and potash requirements 21
2-4. Example of split fertilizer application 22
2-5. Average amounts of available nutrients for different types of manure 22
2-6. Approximate ammonium-nitrogen levels available by livestock type 23
2-7. Estimated per cent of ammonium-nitrogen lost to weather and soil conditions 23
2-8. Fertilization of rye 24
2-9. Interpretation of plant analysis for tobacco 24
2-10. Manganese requirements 25
2-11. Zinc requirements 25
2-12. Soil pH at which lime is recommended 27
2-13. Lime requirements to correct soil acidity 27
2-14. Calculation of the fineness rating of a limestone 28
2-15. Fertilizer calibration 29
2-16.Fertilizer materials—primary nutrients 30
2-17. Fertilizer materials—secondary and micronutrients 30
3-1. Tobacco variety performance (3-year average).. 34
3-2. Tobacco variety performance (2-year average).. 35
3-3. Tobacco variety performance (1-year data) 35

4-1. Final plant populations per 930 cm^2 37

5-1. Weed control in flue-cured tobacco 49
6-1. Plant populations per hectare and acre 50
6-2. Litres of sucker control per hectare 52
6-3. Treatments for nematode control 53
6-4. Multi-purpose fumigant treatments 53
6-5. Application of Aliette WDG 54
6-6. Application of Acrobat MZ 54
6-7. Treatment for cutworms—cover crop 56
6-8. Treatment for cutworms—soil 57
6-9. Treatment for cutworms—at or after planting .. 57
6-10. Treatment for hornworms 58
6-11. Treatment for aphids 58
6-12. Treatment of flea beetles 59

Figures

6-1. Nozzle configuration for freshly transplanted tobacco 55
6-2. Nozzle configuration for mid-sized tobacco 55
6-3. Nozzle configuration for large-sized tobacco... 55

1. Precautions with Pesticides

Pesticide regulations

You must report all major spills, fires or thefts involving pesticides to the Ontario Ministry of the Environment at 1-800-268-6060. (Regulation 914, s. 29)

Pesticide schedules in Ontario

The Ontario Ministry of the Environment reviews each pesticide product offered for sale in Ontario and classifies it into 1 of 6 groupings called Schedules.

Schedule	Who can use it	Pesticide characteristics
1	• licensed exterminator • certified grower • only with approved permit	• very toxic • very persistent • highly mobile
2	• licensed exterminator • certified grower • trainee or technician under supervision of a licensed exterminator (some restrictions apply) • assistant agriculturist under supervision of a certified grower	• toxic, • persistent • moderately mobile
3	• licensed exterminator • certified grower • trainee or technician • consumer	• moderately toxic • moderately persistent • slightly mobile
4	• licensed exterminator • certified grower • trainee or technician • consumer	• low toxicity • non-persistent • non-mobile • containers < 1 kg or < 1 L
5	• licensed exterminator • certified grower • assistant agriculturist under supervision of a certified grower	• very toxic • very persistent • highly mobile • less toxic or less persistent alternative not available
6	• licensed exterminator • certified grower • trainee or technician • consumer	• low toxicity • non-persistent • non-mobile • containers > 1 kg or > 1 L

Certification and training requirements

You must be a certified grower or a licensed exterminator to buy and use Schedule 1, 2 and 5 pesticides.

Pesticide certification for Ontario farmers

Regulation 914 of the *Pesticides Act* requires agriculturists (growers) to be certified to buy and use Schedules 1, 2 or 5 pesticides on land they farm. To become certified, agriculturists must:

- attend the Grower Pesticide Safety Course (GPSC) and successfully complete the examination, and
- meet the definition of a certified "agriculturist" as defined by Regulation 914 under the *Pesticides Act* (i.e. use farm land for agricultural or forestry production, and that land falls within the farmlands property class under Section 7 of the *Ontario Assessment Act*), and
- be at least 16 years old.

Training for agricultural assistants using Schedule 2 or 5 pesticides

All assistants must have formal pesticide safety training that is recognized by the Ministry of the Environment before they can handle or use Schedule 2 or 5 pesticides under the supervision of a certified grower.

- This applies to all assistants, including family members, farm employees and seasonal workers.
- Trained assistants do not have to write an exam.
- Trained assistants must be 16 or older.
- There are 2 training options for assistants. Assistants can:
  - attend a Grower Pesticide Safety Course (GPSC) (an examination is not required), or

- attend an on-farm training session presented by a qualified trained assistant instructor.

For more information and a listing of grower pesticide safety courses and locations, check the Ontario Pesticide Education Program web site at www.ridgetownc.uoguelph.ca/opep/.

To register for a grower pesticide safety course (GPSC) anywhere in Ontario, or for information about trained assistants please:
- call 1-800-652-8573
- fax 1-519-674-1589
- e-mail opep@ridgetownc.uoguelph.ca.

Certification and licensing for commercial exterminators

For updates to training requirements under Regulation 914 of the *Pesticides Act*, refer to the Ministry of Environment web site at www.ene.gov.on.ca or phone 1-888-565-4923.

You must be a licensed exterminator if you plan to apply pesticides as a business. This includes farmers who custom-apply pesticides for other farmers and charge a fee for this service. Licensed exterminators who are self-employed must hold an operator licence as well as the appropriate exterminator licence. Exterminator licenses are valid for 5 years.

To become a licensed exterminator, you must:

- complete a home study course and certification exam through Ridgetown College, University of Guelph, and

- send proof of certification (letter of successful completion of the exam(s)) and a fee to the Ministry of the Environment to obtain your exterminator licence. (See *APPENDIX B: Ontario Ministry of Environment Pesticides Control Offices* on page 69.)

Training for technicians working as assistants to licensed exterminators

Assistants to licensed exterminators must become Technicians to mix, load or apply all Schedule 3, 4 and 6 pesticides and most Schedule 2 pesticides (some restrictions apply), under the indirect supervision of a licensed exterminator. Technicians cannot mix, load or apply Schedule 1 or 5 pesticides. Technician cards are valid for 2 years. To become a technician, you must:

- complete an MOE-approved academic course and exam and

- complete practical training with a licensed exterminator.

For more information about certification and licensing requirements for licensed exterminators and training for technicians, contact Ontario Pesticide Training & Certification:
- call 1-888-620-9999
- fax to 519-674-1585
- check the web site at www.ridgetownc.uoguelph.ca/optc.

General precautions

Always read the label:

- Before you buy a pesticide.
- Before you begin to use a pesticide.
- Before you store a pesticide or dispose of it.

Learn about the health hazards and toxic properties of the pesticide you are using. Consult the product label, Material Safety Data Sheets (MSDS), or manufacturer for this information. Check the company web sites for MSDS information.

Protect yourself when you use pesticides

- **Make sure someone knows** where you are working, what pesticides you are handling and how long you expect the job to take.

- **Post emergency numbers**, including the Poison Information Centre and Spills Action Centre, near all telephones.

- **Keep a list of the names and the Pest Control Products (PCP) Act Registration Numbers of all pesticides you handle**. Keep a file of the pesticide label booklets for all products you use. Make sure your co-workers and family members know where this list or file is in case of an accident. The list of chemicals used for tobacco is in *Table 1-5. Pesticides used in producing flue-cured tobacco* on page 14.

- **Have plenty of clean water, soap and paper towels, and an extra set of gloves and coveralls nearby at all times** in case a pesticide contaminates your clothing or skin.

- **Wear the correct protective clothing and equipment, and be sure all items are clean and in good repair before you put them on.**

- **Never smoke, chew tobacco, eat or drink when you handle pesticides.** Never carry tobacco or food in your clothes, and never leave tobacco, food or beverages in areas where you handle or store pesticides.

- **Change your clothes and wash your hands and face before you eat, drink or smoke.**

- **Wash your hands before you use the toilet,** as well as after. The skin in your groin area absorbs pesticides very easily.

Protect other people, livestock, pets, water and sensitive crops

- Buy and store only what you need.
- Prevent drift.
- Keep pesticides out of water.
- Clean up spills quickly and safely.
- Dispose of containers and waste pesticide safely.

Read and follow pesticide label information

Know the hazard symbols and words

Learn these symbols and words — they could save your life!

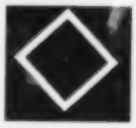
Check the label for special warnings about eye hazards and skin hazards.

The front panel of the pesticide label may also contain warnings that tell you the product is corrosive to eyes, or is a skin or eye irritant.

Four important symbols and words show the potential hazards of pesticides.

Hazard symbol	Signal word
	Poison
	Corrosive
	Flammable
	Explosive

The hazard symbol always appears inside one of the shapes shown below. These shapes and their warning words tell you the degree of hazard of the pesticide. **The greater the number of sides to the shape, the more hazardous the product.**

	Warning symbol	Signal word
Triangular shape means low hazard (3 sides)		**Caution**
Diamond shape means moderate hazard (4 sides)		**Warning**
Octagonal shape means high hazard (8 sides)		**Danger**

Re-entry periods

Re-entry period is the minimum amount of time that must pass between the time the pesticide was applied and the time that workers can go into the crop area without wearing personal protective equipment. If workers enter fields without wearing protective equipment too soon after pesticides have been applied they may experience poisoning. Such poisoning can result from handling treated plants or from inhaling pesticide vapours.

Some pesticides, like parathion, have labels that carry a warning about working in treated crops. Follow the label recommendations.

When applying Lannate (methomyl) you must wait at least 24 hours before working in the treated crop without protective equipment.

Days to harvest (preharvest) intervals, pregrazing and feeding intervals

These intervals state the minimum amount of time that must pass between the last pesticide application and the harvesting of the crop, or the grazing or cutting of the crop for livestock feed. If you harvest a crop before the preharvest interval has passed, there may be pesticide residues in excess of the Maximum Residue Limits (MRL) set by Health Canada. When crops with persistent residues are fed to livestock, the pesticides may poison the animal or may contaminate the milk or meat.

To avoid exceeding the Maximum Residue Limits, always follow the label.

Crop rotation

Some pesticides can persist in treated soil. Crops sensitive to that pesticide may be injured if they are planted too soon after the treated crop is harvested. Some labels state a minimum waiting time that must pass before it is safe to plant sensitive crops.

Total number of applications

Some product labels state the total number of applications of that pesticide that can be made during a growing season. These limits prevent food residues, crop damage, soil residues or pest resistance.

Buffer zones

Buffer zones are areas left untreated to protect an adjacent area such as a pond, stream, sensitive crop, non-target crop, wetland, woodland, etc.

Human health

Risks of pesticide use

Each time you handle a pesticide, you are at some risk. The amount of risk depends on 2 things: the toxicity of that pesticide and your exposure to it.

Risk = Toxicity X Exposure

Toxicity is a measure of how harmful or poisonous the pesticide is. There are 2 types of toxicity:

- **Acute toxicity** — the toxic response that results from a single exposure to the pesticide. The symbols and words on the front panel of a pesticide label give you information about the acute toxicity.
- **Lethal Dose 50% (LD_{50})** is a measure of acute toxicity. It is the dose (mg of product per kg of body weight) that will kill 50% of the test animals within a stated period of time (24 hours to 7 days). Products with low LD_{50} ratings are highly toxic.

Lannate (methomyl) is a product listed in this publication with a high acute toxicity.

- **Chronic toxicity** — the toxic response that results from repeated exposures to small doses of a pesticide over a longer period of time. These toxic effects may not appear for months or years after exposure to the pesticide. The symbols on the label do NOT give information about the chronic toxicity of the product. Use protective clothing and equipment to help reduce exposure and the risk of chronic effects.

Cholinesterase blood tests

Organophosphorus and *carbamate* pesticides can affect your nervous system. These pesticides can change your serum and red blood cell levels of an enzyme called acetyl cholinesterase. Your body uses this enzyme to transmit messages through your nervous system. If your cholinesterase levels fall, you can experience symptoms including trembling, twitching, blurred vision, difficulty breathing and heart difficulties.

If you use any of these pesticides routinely have your cholinesterase blood tested regularly (see *Table 1-1. Pesticides that affect cholinesterase levels in blood* on page 5). Your family doctor can arrange these tests, which are covered by OHIP. **Have your first test before you begin to handle these pesticides.** That shows the baseline (normal) cholinest-

erase level for your body. During the spray season, if you are spraying organophosphorus or carbamate insecticides regularly for several weeks, have a cholinesterase blood test every **7–10 days**. If your cholinesterase level drops to below one-half of your baseline level, then you are showing signs of pesticide poisoning and **you must remove yourself from exposure** to these pesticides until your cholinesterase level returns to normal.

Table 1-1. Pesticides that affect cholinesterase levels in blood

Common name	Trade name
acephate	Orthene
carbaryl	Sevin
chlorpyrifos	Lorsban, Pyrinex
diazinon	Diazinon
methomyl	Lannate
pirimicarb	Pirimor
trichlorfon	Dylox

Exposure is a measure of the contact you have with a pesticide. You can be exposed to a pesticide in 3 ways.

- **Dermal exposure** occurs through your skin or eyes. The amount and rate of pesticide that may be absorbed depends on several things, including:
  - your skin condition. If your skin is moist, or if you have a rash, broken skin or scratches, a pesticide will be absorbed more easily.
  - the part of your body that is exposed. Your eyes, genital area, scalp and ear canals absorb pesticides at a higher rate than your hands or arms. Your eyes absorb pesticides at a rate of 100%.
- **Respiratory exposure** (inhalation) occurs when you inhale small spray particles, dust, gases or vapours.
- **Oral exposure** occurs when a pesticide enters your mouth or you swallow a pesticide.

First Aid

1. Always protect yourself from injury first. Don't become another victim. Always put on protective clothing and equipment before you enter a contaminated area or handle a contaminated victim.
2. Check to see if the victim is breathing.

   If the victim is not breathing:
   - Straighten the victim's airway and check for breaths.
   - If the victim does not begin to breathe, administer artificial respiration until the victim begins to breathe on their own.
   - Do not contaminate yourself, especially if the victim has pesticide or vomit around his face or mouth. Use a face shield airway with a one way valve. Do not breathe the exhaled air from the victim.
   - Perform CPR if the victim's pulse disappears. Only perform CPR if you are trained to do so.

   If the victim is breathing, but unconscious:
   - Place the victim in the recovery position (on the side with the head turned slightly to one side). If the victim vomits, try to keep the airway clear.
3. Stop the exposure to the pesticide. Move the victim away from the contaminated area. Remove all contaminated clothing. Use soap and water to wash any skin exposed to the pesticide.
4. Check the Four Basic Facts:
   - **Identify the pesticide**. Look for the label, container or leftover pesticide.
   - **Quantity**. How much product was the victim exposed to?
   - **Route of entry**. How did the pesticide enter the body? Did it enter through the mouth, skin, eyes or lungs?
   - **Time period**. How much time has passed since the victim was exposed to the pesticide, and how long was the exposure? Were the symptoms immediate or did the poisoning occur as a result of using the pesticide over a longer period of time?

Don't waste time. If you can't answer these questions quickly, be ready to tell emergency personnel whatever you can.

5. Call an ambulance or the Poison Information Centre.

6. Start the first aid treatment appropriate for the route of entry.

7. Make sure the patient gets medical attention. First aid is not a substitute for professional medical help.

If symptoms of illness occur during or shortly after handling a pesticide, go to a hospital. Take the pesticide label, Material Safety Data Sheet (MSDS), or pesticide container with you. Do not transport the container in the passenger compartment of the vehicle.

Refer to the Emergency Procedures for Pesticide Poisoning on the inside back cover.

Protective clothing and equipment

Choose and wear the appropriate protective clothing and equipment

Make sure your protective clothing and equipment:

- is what you need for the job
- fits properly, and
- is clean and in good repair and working condition.

The protective clothing and equipment you need to wear depends on:

- **the pesticide you are using**. READ THE PRECAUTIONS SECTION OF THE LABEL TO KNOW WHAT TO WEAR.

- **the job you are doing**. For example, you need more protection when you handle concentrated pesticide, or when you mix and load your sprayer.

- **the type of application**. Enclosed space or air blast sprayer applications made with open tractors require more equipment.

Each person who is working with pesticides needs **their own** set of protective clothing and equipment. Consult the technical expert at your safety supply company to make sure that you purchase the appropriate equipment and that it fits the user.

For ALL pesticides, always wear:

- a water-repellent hat such as a hard hat or waterproof rain hat. Sometimes you need to protect your entire head and neck. For example, if you apply pesticides in a greenhouse, apply dusty formulations or use an air-blast sprayer. In these types of situations, wear a hood or hat that protects your ears and ear canals. Do not wear hats made from cloth. Baseball-style caps absorb pesticides and are not safe.

- long pants and a shirt with long sleeves, or a coverall. Coveralls can be reusable or disposable. Reusable coveralls are normally cotton or polyester and should be tightly woven. Disposable coveralls should be designated for pesticide use. Water-resistant coveralls are preferred because cotton, denim and cotton-polyester pants cling to the skin if they get wet, increasing the risk of dermal exposure.

- chemical resistant gloves (unlined). Use neoprene or nitrile gloves, unless the label states otherwise. Do not wear rubber gloves as many pesticides can break down the rubber material. Wear your gloves under your sleeves with the top cuffed.

- chemical resistant boots (unlined).

Read the label. It describes what extra protective clothing and equipment to wear. For some pesticides you may also need to wear:

- goggles. Use safety goggles with indirect vents so that splashes do not enter eyes. Regular eyeglasses don't provide complete protection. Never wear contact lenses when you handle pesticides.

- face shield

- chemical resistant apron

- respirator. A respirator is a unit that covers your mouth and nose to prevent spray droplets, small particles, and vapours from getting into your lungs. **A dust mask is not a substitute for a pesticide respirator.** When you buy a respirator or replacement cartridges, make sure the cartridges and prefilters protect you against organic vapours. For more information about respirators, refer to the *Grower Pes-*

ticide Safety Course Manual, Ridgetown College, University of Guelph.

You may need more protection, such as **canister gas masks or self-contained breathing apparatus (SCBA)** when you apply:

- any pesticide in an enclosed area, or
- fumigants, gases, vapours or smokes.

ALWAYS wear a respirator when you work with fumigants, gases or vapours, or when you apply pesticide in an enclosed area.

Use organic vapour tractor cab cartridges

If you use a tractor with a cab when you spray, these tractor cab cartridges work the same way as an air-purifying respirator. These cartridges and pre-filters **must** be replaced and maintained regularly to provide continued protection.

When you use air blast sprayers and mist blowers and tractors without cabs

Wear the appropriate respirator as well as a waterproof suit, head covering, chemical resistant gloves, boots, and eye protection.

After the spray application, clean your protective equipment and the tractor. If you have not decontaminated the tractor, do not operate it without wearing protective clothing and equipment.

Safety supply companies

Consult the safety supply companies of your choice for help in selecting your protective clothing and equipment. (See Table 1-2.)

Table 1-2. Safety supply companies in Ontario

3-M Canada Inc.	Occupational Health and Environmental Safety, Box 5757 London, ON N6A 4T1	(519) 452-6165 1-800-364-3577 Fax: (519) 452-4660
Acklands Grainger	90 W. Beaver Creek Rd. Richmond Hill, ON L4B 1E7	(905) 731-5516 1-800-668-8989 Fax: (905) 731-2798
Aearo Canada	7115 Tomken Rd. Mississauga, ON L5S 1X7	(905) 795-0700 1-800-387-4304 Fax: (905) 564-5250
Dutch Industries "Protect-Air Cab Filter"	Huron Tractor, Box 1300 Exeter, ON N0M 1S3	(519) 235-1115 Fax: (519) 255-1939
HAMISCO	3392 Wonderland Rd. London, ON N6L 1A8	(519) 652-9800 1-800-668-9800 Fax:(519) 652-9661
Kappler Canada	Box 1687 20 Ryan Place Brantford, ON N3T 5V7	(519) 752-4369 1-800-387-9326 Fax: (519) 752-2161
Levitt-Safety (Eastern) Limited	2872 Bristol Circle Oakville, ON L6H 5T5	(905) 829-3299 1-800-668-6153 Fax: (905) 829-2919
MSA Canada Inc.	148 Norfinch Dr. North York, ON M3N 1X8	(416) 667-9400 1-800-267-0672 Fax: (416) 663-5908
Mitt & Robe Co.	751 Norfolk St. N. Simcoe, ON N3Y 3R6	(519) 428-4050 1-877-893-6565 Fax: (519) 428-5142
Plant Products Co. Ltd.	314 Orenda Road Brampton, ON L6T 1G1	(905) 793-7000 1-800-387-2449 Fax: (905) 793-9632
Safety Express	4060B Sladeview Cres., Unit 2 Mississauga, ON L5L 5Y5	(905) 608-0111 1-800-465-3898 Fax: (905) 608-0091
The Saint George Company (Suppliers of Kasco Helmets)	P.O. Box 430 20 Consolidated Drive Paris, ON N3L 3T5	(519) 442-2046 1-800-461-4299 Fax: (519) 442-7191

Care of protective clothing and equipment

- After you complete the spray operation, clean all protective clothing and equipment.
- Never let children, pets or livestock come in contact with contaminated clothing or equipment. Make sure they do not come into contact with the puddles of water that result from cleaning your equipment.
- Wash your gloves with soap and water, then *leave them on* to remove your other protective clothing and equipment.
- Always remove protective clothing and equipment outdoors. If a granular pesticide was used, shake the clothing outdoors in a safe place, emptying pockets and cuffs.
- Throw out clothing contaminated by spills of highly toxic or concentrated pesticide. Place clothing in a plastic bag and take it to a landfill site.
- **Coveralls and other spray clothing must be washed separately from other clothes.** Wash after each use. Place them in a plastic bag and keep them separate.
- With your hands still protected by gloves, wash protective equipment. It is best to wash equipment outdoors. If you do not have an outside clean-up area, keep certain buckets just for equipment clean up. Mark them and keep them in a special place. Wash the inside and outside of your goggles, hat, boots, and any water-repellent clothing in warm soapy water, rinse well and let them air-dry.
- Remove the cartridges and prefilters from the respirator.
- Discard cartridges, canisters and filter pads when breathing becomes difficult, when you notice a pesticide taste or odour, or at the interval set by the manufacturer.
  - Note the date the cartridge is first used.
  - Remove cartridges and filter pads from the face piece and store in clean, sealed plastic bags.
  - Wash the face piece in warm soapy water, rinse thoroughly, and dry in a well-ventilated area. Air-drying prevents damage to the inlet and outlet valves.
  - Never use alcohol or other solvents for cleaning, as they damage the rubber and plastic.
- Next, wash the outside of your boots and gloves with soapy water and remove them.
- After removing boots and gloves, wash them inside and out with detergent and water, rinse thoroughly, and dry in a well-ventilated area.
- Place all dry articles in a clean storage area until next use.

How to wash your spraying clothes

Never mix spray clothing with household laundry. All clothing used for spraying must be stored and washed separately from other clothing. Wash after each use. Remember to use chemical resistant gloves to handle pesticide-contaminated clothing.

- Presoak clothing before washing. Use 1 of 3 methods:
  - hose-off garments outdoors
  - soak in separate tub or pail
  - use the prewash cycle in automatic washer.
- Place clothing directly into the washing machine. Wash only a few garments at a time. Do not wash with other family clothes.
- Use hot water, the highest water level, and the longest cycle, with heavy duty detergent. Wash as you would for heavily soiled clothing.
- Wash clothing again.
- After washing, hang outside (preferably in bright sunlight) until completely dry. Do not use the clothes dryer.
- Clean the washing machine. Run the washing machine through one complete cycle using only detergent and hot water. (No clothing.)

Personal hygiene

- Always wash your hands and face before you eat, drink or smoke.
- **When you are finished for the day, take a bath or shower as soon as possible**. The longer a pesticide remains on your skin, the greater the risk it will be absorbed into your body.

- Wash your hair and under your fingernails. Shower with lots of soap and water.
- Always change into clean clothes.
- Wear clean work clothes every day. A small spill on the previous day's clothes may seem unimportant, but wearing the same clothing again without washing it prolongs the exposure and increases your risk.

Protect the environment

Protect water sources

- You must use an anti-backflow device to prevent back siphoning when drawing water from wells, ponds, streams or other sources.
- Mix pesticide and load the sprayer away from any water supply, including wells, ponds or streams.
- Use buffer zones (untreated areas) when you apply pesticides to avoid contaminating surface water, wells, ponds or streams. Check the product label for specific buffer zone distances.

Reduce and manage pesticide spray drift

Spray only when winds are light to moderate. If you notice drift is occurring because of the wind, **stop spraying** until the wind subsides. Do not apply pesticides if the wind is blowing towards susceptible crops or environmentally sensitive areas such as watercourses.

- Read the product label for information regarding buffer zones, water volumes and recommended nozzles.
- Use buffer zones around all watercourses, wells and neighbouring fields that contain sensitive crops. If the label does not state a specific buffer zone distance, leave an untreated area of natural vegetation.
- Select the recommended sprayer application rate (L/ha).
- Select the correct nozzle. Where practical, use air induction/venturi nozzles. These nozzles significantly reduce drift when compared to conventional nozzles.
- Select the correct nozzle-to-target distance.
- Use spray plume protection where practical or available (hoods, shrouds, screens and air curtains).
- Use drift-reducing adjuvants in the spray tank as directed by the label.
- Use wick weeders instead of spraying, when possible.

For more information about spray drift consult the OMAF/Agriculture and Agri-Food Canada booklet *Best Management Practices — Pesticide Storage, Handling and Application* and the Ontario Pesticide Education Program (Ridgetown College) videos *How to Manage Spray Drift* and *Spray Drift Reduction through Air Induction.*

Prevent bee poisoning

It is important to protect bees when you spray. Honeybees, as well as other bees and insects, are important pollinators of crops. Many crops also offer bees important sources of pollen for honey production.

If you choose to use insecticides for insect control, take these steps to prevent harming bees when you spray:

- Before you apply a pesticide, advise local beekeepers so that they can move colonies out of the danger area. Contact the provincial apiarist at 1-888-466-2372 for a list of beekeepers in your area.
- Do not spray any flowering crop on which bees are foraging. If you must apply insecticides, spray after 7 in the evening when the bees are not foraging. If this is not possible, spray before 7 in the morning. Bees usually do not forage at temperatures below 13°C.
- Do not apply insecticide on windy days to prevent drift toward any nearby hives.
- When there is a choice, choose the product formulation that is less hazardous to bees. Dusts are more toxic than sprays. EC formulations are less toxic than WP formulations.
- Under the *Bees Act* it is an offence to spray in orchards while there is bloom on the trees.

Most organophosphate and carbamate insecticides are highly toxic to bees. Examples of insecticides used in crop production that are toxic to bees are listed in *Table 1-3. Relative toxicity of insecticides to honeybees*:

Read each pesticide label for specific precautions regarding bees.

Table 1-3. Relative toxicity of insecticides to honeybees

Trade name	Common name
Group 1. Very toxic. Do not apply to flowering crops or weeds.	
Pounce	permethrin
Diazinon	diazinon
Lannate	methomyl
Lorsban, Pyrinex	chlorpyrifos
Malathion	malathion
Orthene	acephate
Ripcord, Cymbush	cypermethrin
Sevin	carbaryl
Group 2. Moderately toxic. Apply only during late evenings or early mornings.*	
Decis	deltamethrin
Dylox	triclorfon
Pirimor	pirimicarb

*Unusually low temperatures at time of application may cause insecticides to remain toxic up to 20 times longer than during warm weather. High temperatures in the early morning or late evening may extend active foraging by bees.

Disposal of pesticides and empty containers

Triple or jet rinse your empty pesticide containers

Unrinsed pesticide containers are not really "empty". They may still hold about 1% of the original amount of pesticide. Although this figure sounds low, it is still a hazard to humans, animals, and the environment. To reduce the hazard, rinse each container 3 times as the spray tank is filling. Use either the manual triple-rinse technique, or a specially designed device for rinsing containers. Paper or cardboard containers are often strong enough to be rinsed. If it is possible, rinse these containers as well as plastic ones.

To triple rinse

1. Fill the empty container at least 10% full of the diluting material (usually water).
2. Cap, then shake or roll the container so that the inside surfaces of the container are well rinsed.
3. Pour rinsings into the spray tank.
4. Repeat steps 1–3 twice more.

Remember to check the container after you have finished rinsing. Make sure no pesticide has been left behind as a cake or paste on the bottom of the container.

Rinsing devices

Rinsing devices use pressurized water to clean the container. They are just as effective as triple rinsing but take less time. Follow the manufacturer's instructions.

Triple rinse!

How to dispose of empty, triple-rinsed containers

Never reuse empty pesticide containers. They may be handy, but there is still some risk, even if the containers are triple rinsed. Never give empty, rinsed containers to anyone, especially not children. Dispose of them promptly.

Regulation 914 of the *Pesticides Act* regulates how pesticide containers are to be disposed of in Ontario.

For metal, plastic or glass containers

Dispose of an empty metal, plastic, or glass container that has been used to hold a Schedule 1, 2, 3*, 5 or 6* (*non-domestic) pesticide by triple rinsing or jet rinsing using clean water, or another appropriate solvent

AND either

- taking it for recycling to a pesticide container depot

OR

- taking it to a licensed waste disposal site. (Reg. 914, s. 27)

Once properly rinsed, puncture the containers so they cannot be reused and to make sure the rinse water is totally out of the container.

It is often more convenient to store empty, rinsed containers until you have collected enough to make a trip to the recycling pesticide container depot or the waste disposal site. If you store containers, keep them in a dry safe place, such as the storage area, until you can dispose of them properly.

Recycling

The Ontario Pesticide Container Recycling Program is available to growers and commercial exterminators. Through this program, **clean, triple rinsed, plastic/metal pesticide containers** (up to 23 L in size for plastic and 20 L in size for metal) can be returned to pesticide container depots located throughout the province. To locate the pesticide container recycling depot closest to you, call the Ontario Pesticide Education Program at 1-800-652-8573.

Future Farm Supply in Aylmer has a recycling pesticide container depot to collect empty metal drums that contained sucker oil and fumigants used in tobacco and fruit production.

For paper and cardboard containers

Dispose of a paper or cardboard container that has been used to hold a Schedule 1, 2, 3*, 5 or 6* (*non-domestic) pesticide by triple rinsing or jet rinsing (if possible) using clean water

AND either

- burning, (if allowed by municipal bylaws) in circumstances that persons and animals are kept out of any smoke produced and any smoke is directed away from buildings, highways, roads, or outdoor areas frequented by the public

OR

- taking it to a licensed waste disposal site. (Reg. 914, s. 27)

Paper or cardboard containers are often rigid enough to withstand rinsing. If possible, triple rinse these containers as you fill the tank. Then burn the containers in an isolated area on your farm.

Be very careful around the smoke. It may contain toxic fumes from the burning pesticide. Be certain there is no chance that a person or animal may breathe in this smoke. Make sure the smoke does not drift toward buildings, roads, or any public outdoor areas.

These containers can also be taken to a local waste disposal site in the same way as metal, plastic, or glass containers. If you can't dispose of them immediately, make sure containers are kept in a secure place such as the pesticide storage area.

Unwanted pesticides

If you have pesticides you do not need or cannot use, be sure to dispose of them safely.

- Contact the supplier. It is sometimes possible to return unused pesticide if it is still in its original container.
- If you cannot find any way to use the product as shown on the label, then the Ministry of the Environment requires that waste be disposed of by licensed waste haulers to a licensed waste disposal site. Look in the Yellow Pages of your telephone directory under Liquid Waste Removal.
- Watch your local paper for Municipal Waste Collection Days or contact your municipality. If your municipality has no waste collection days, encourage them to sponsor such an event. On these days, you can turn over surplus pesticide concentrates (maximum 25 L) for disposal.
- Consult with the regional Ministry of the Environment Office for more information. (See Appendix B on page 69 for a list of MOE offices.)

Surplus spray mix

The best way to dispose of any excess spray mix is to find other fields that require an application of this pesticide. Before spraying, check the label to make sure the pesticide is registered for use on that crop.

If you can't find another field to spray, then dilute the remaining spray mix by adding 10 parts of water for each 1 part of spray mix. This diluted solution can be safely applied to the treated area as long as you do not exceed the pesticide rate recommended on the label. Be sure to check the label for any restrictions about crop rotation, days to harvest, or surplus spray mix disposal.

NEVER respray the treated crop with undiluted spray mix. Spraying an area twice will double the recommended pesticide rate. This may cause illegal pesticide residues in the harvested crop or harmful residues in the soil that can cause crop damage.

Soluble packaging options

Choose soluble packages that dissolve in the spray tank to reduce container disposal. Water-soluble packaging is used for dry flowable and wettable powder formulations of pesticides and is available under names such as Clean Pak, Solupak and Toss-N-Go. In most cases, the water-soluble packaging material is PVA (polyvinyl alcohol). This material dissolves completely when added to the water in the sprayer tank according to instructions.

Read all labels and instructions carefully. For more details contact your vendor.

Keep soluble pouches dry until you add them to the spray tank.

- Do not handle pouches with wet hands or wet gloves.
- Do not remove pouches from the outer package until you are ready to add them.
- Always reseal the outer package to protect the remaining pouches from moisture.

Mixing soluble pouches

- Consult product labels for specific mixing instructions for each product.
- Fill the spray tank 1/4 full of water and have the agitator running — then add the water-soluble pouches to the tank.
- Most pouches dissolve completely within 5 minutes, depending on the water temperature and the degree of agitation.
- As the tank continues to fill, add any other compatible pesticides.

Do not add:

- a pesticide that is incompatible with the PVA packaging material. PVA material is not soluble with summer-type oils (e.g., Superior Oil).
- any material containing boron (e.g., Solubor) chelated micronutrients or water-soluble fertilizers. This combination is likely to cause a sticky, insoluble substance in the tank. If you apply boron, chelated micronutrients or water-soluble fertilizers, make sure you completely empty and rinse the spray tank before you use any product packaged in PVA.

Storing pesticides

Ontario's *Pesticides Act* and Regulation 914 gives storage requirements for storage facilities. The storage requirements you must follow depend on which Schedules of pesticides you store. See *Table 1-4. Pesticides Act storage requirements.*

Table 1-4. *Pesticides Act* storage requirements

	Sch. 3, 4 & 6	Sch. 2	Sch. 1 & 5
No contact with food or drink	◆	◆	◆
Not impair health/safety	◆	◆	◆
Clean & orderly manner	◆	◆	◆
Warning signs posted on storage buildings	◆	◆	◆
Warning signs posted on unattended vehicles	◆	◆	◆
Emergency telephone numbers posted	◆	◆	◆
Ventilated to outside		◆	◆
Limited access (locked)		◆	◆
No floor drain		◆	◆
Safety equipment available		◆	◆
Area used exclusively for pesticides			◆

See also OMAF Factsheet, *Pesticide Handling Facilities*, Order No. 94-037.

Pesticide spills

Protect yourself before you begin to clean up any spill. Clean up spills immediately.

In the case of minor spills:

- for liquids, cover the spill with a thick layer of absorbent material such as kitty litter, vermiculite or dry soil. Sweep or shovel the material into a waste drum.
- for powders and granulars, sweep or shovel the material into a waste drum.

In the case of a major spill:

- remove any people or animals from the spill area.
- stop the spill from spreading.

- do not let the pesticide enter any watercourse.

If a pesticide spill causes, or is likely to cause, an adverse effect, you must notify the Ministry of Environment, Spills Action Centre at 1-800-268-6060 (24 hrs a day, 7 days a week) and the municipality.

For information on preventing spills see OMAF Factsheet, *Ways to Avoid Pesticide Spills*, Order No. 96-025.

Application Procedures

Sprayers

- Sprayers that can deliver enough litres per hectare for adequate coverage are satisfactory for applying emulsion-type insecticides.
- If 2,4-D or related herbicides are used, clean the sprayers thoroughly with detergent containing ammonia to prevent crop damage.
- Adequate agitation is essential when applying wettable powder formulations.
- Pumps should be capable of delivering the flow and pressure required as well as being compatible with materials sprayed.
- Keep in mind that the higher the pressure, the greater the danger of drift to other crops.
- Calibrate your sprayer at least twice during the growing season with each set of nozzles used. The wear on nozzles and other parts will alter the amount of spray delivered.
- Check all nozzles for flow rate at least once a year. Replace nozzles when their output is 10% greater than rated output.
- For information on calibration, see the current OMAF Publication 75, *Guide to Weed Control* or the OMAF web site at www.gov.on.ca/OMAF/english/crops/.

General precautions and requirements for fumigants (gases, vapours and fumes/smokes)

Read and follow all instructions on the product label regarding protective clothing and equipment, aeration of treated areas, and re-entry periods.

- Lock the building and post warning signs.
- **If you use a fumigant gas** to fumigate a structure you must hold the appropriate license and obtain a permit issued under Ontario's *Pesticides Act*. To apply for a permit, contact the regional pesticides officer with the Ontario Ministry of the Environment.
- As a safety precaution, have someone else who is wearing personal protective equipment help with the fumigation. (This is a requirement for all fumigant gas use.)
- **When you handle methyl bromide,** do not wear gloves. You must wear a self-contained positive-pressure breathing apparatus.
- **When you handle aluminum phosphide**, use cotton gloves and wear a full-face mask respirator with an acid gas canister, or a self-contained positive-pressure breathing apparatus.

For more information, obtain *Structural Fumigation Procedures* (September 1998 edition) from the Ontario Ministry of the Environment.

Band spraying

Check the directions on the product label. Some labels give specific nozzle recommendations and formulas to determine band application rates.

You need to decide how much spray mix to prepare so that you apply the recommended rate over the band area. To know how much to mix, you first need to calculate the size of the entire treated area.

$$\text{Total area of bands (ha or ac)} = \text{total area of planted field (ha or ac)} \times \frac{\text{band width (cm or in)}}{\text{row spacing (cm or in)}}$$

Seed treatments

Remember that seed treatment products are also pesticides.

- Seed dressings and seed treatments are poisonous to people and animals.
- Wear protective clothing and equipment when you are treating seed or handling treated seed. Protect your skin—wear a long-sleeved shirt and long pants or coveralls and wear neoprene or nitrile gloves. Protect your eyes with goggles or a face shield or both. Wear a respirator to protect your lungs from dusts and vapours.
- Wash thoroughly after finishing the treatment or handling the treated seed.
- Never feed treated seed to animals.
- Keep treated seed out of the reach of children.
- Destroy all the bags that have held treated seed as recommended in the container disposal section by burning or by taking them to a licensed waste disposal site.

Application by plane or helicopter

Any person who applies pesticide from an aircraft in Ontario must hold an aerial exterminator licence. In addition, a permit is required to purchase and apply pesticides by air for the following:

- applications to surface water, e.g. ponds, lakes, rivers (exceptions in some cases)
- applications to forests as defined in the *Crown Forest Sustainability Act*
- applications of any Schedule 1 or 5 pesticide or a Schedule 2 pesticide containing 2,4-D, 2,4-DB, mecoprop, MCPA, MCPB, dichlorprop, dicamba, picloram, paraquat or trichlopyr except when made to agricultural land.

Be sure that any pesticide you apply by air has specific instructions for aerial use on the label.

Take extra precautions when using insecticides applied by air that are toxic to honeybees, such as Sevin (carbaryl).

Table 1-5. Pesticides used in producing flue-cured tobacco

Common name cross-referenced with trade name examples[1]		Use[2]	Formulation[3]	Active ingredient	Conversion factor[4]	Schedule	Winter storage[6]
acephate	Orthene	i	SP	75%		2	C
Acrobat MZ	dimethomorph + mancozeb	f	WP	9% + 60%		2	
Aliette WDG	fosetyl-Al	f	Gr	80%		2	
bacillus thuringiensis	Dipel	i	WP	16,000 IU/mg		3	
bacillus thuringiensis	Thuricide	i	Li	4,000 IU/mg		3	
Basamid	dazomet	ifnh	Gr	98%	1.02	2	C
Benlate	benomyl	f	WP	50%		3	
benomyl	Benlate	f	WP	50%		3	
carbaryl	Sevin	i	WP, WP, Su	50%, 80%, 480 g/L		3	
Chiptac	fatty alcohol (n-decanol)	s	Li	78%		3	
chloropicrin	Chloropicrin 100	ifn	Li	99%		5	
Chloropicrin 100	chloropicrin	ifn	Li	99%		5	
chlorpyrifos	Lorsban	i	EC, WP	480 g/L, 50%		2	
chlorpyrifos	Pyrinex	i	EC	480 g/L		2	
Cymbush	cypermethrin	i	EC	250 g/L		2	
cypermethrin	Cymbush	i	EC	250 g/L		2	
cypermethrin	Ripcord	i	EC	400 g/L		2	
dazomet	Basamid	ifnh	Gr	98%	1.02	2	C
Decis	deltamethrin	i	EC	50 g/L		2	
Delete	fatty alcohol (n-decanol)	s	Li	688 g/L		3	
deltamethrin	Decis	i	EC	50 g/L		2	

Table 1-5. Pesticides used in producing flue-cured tobacco

Common name cross-referenced with trade name examples[1]		Use[2]	Formulation[3]	Active ingredient	Conversion factor[4]	Schedule	Winter storage[5]
Devrinol DF	napropamide	h	DF	50%	2	3	C
diazinon	Diazinon	i	WP	50%		2	
Diazinon	diazinon	i	WP	50%		2	
1,3-dichloropropene	Telone II	n	Li	94%		2	
1,3-dichloropropene + chloropicrin	Telone C-17	ifn	Li	78% + 16.5%		2	
1,3-dichloropropene + methyl isothiocyanate	Vorlex Plus	ifnh	Li	40% + 20%	1.74	2	B
1,3-dichloropropene + methyl isothiocyanate + chloropicrin	Vorlex Plus CP	ifnh	Li	34% +17% + 15%	1.39	2	B
dimethomorph + mancozeb	Acrobat MZ	f	WP	9% + 60%		2	
Dipel	bacillus thuringiensis	i	WP	16,000 IU/mg		3	
Dithane	mancozeb	f	WP, Gr	80%, 75%		3	
Dylox	trichlorfon	i	EC	420 g/L		3	
Emtrol	fatty alcohol (n-octanol + n-decanol)	s	Li	731 g/L		3	
Emtrol Ten	fatty alcohol (n-decanol)	s	Li	722 g/L		3	
fatty alcohol (n-decanol)	Chiptac	s	Li	78%		3	
fatty alcohol (n-decanol)	Delete	s	Li	688 g/L		3	
fatty alcohol (n-decanol)	Emtrol Ten	s	Li	722 g/L		3	
fatty alcohol (n-decanol)	Gold Leaf C-10	s	Li	680 g/L		3	
fatty alcohol (n-decanol)	Pfizol-10	s	Li	688 g/L		3	
fatty alcohol (n-octanol + n-decanol)	Emtrol	s	Li	731 g/L		3	
fluazifop-p-butyl	Fusilade II, Venture L	h	EC	125 g/L	8	5	C
formaldehyde	Formalin	f	Sn	37%		3	
Formalin	formaldehyde	f	Sn	37%		3	
fosetyl-Al	Aliette WDG	f	Gr	80%		2	
Fusilade II	fluazifop-p-butyl	h	EC	125 g/L	8	5	C
glyphosate	Roundup Transorb	h	Sn	360 g/L	2.78	6	B
glyphosate	Loredo, Renegade, Roundup, Wrangler	h	Sn	356 g/L	2.81	3	B
glyphosate TMS	Touchdown 480	h	Sn	330 g/L	3.03	6	B
Gold Leaf C-10	fatty alcohol (n-decanol)	s	Li	680 g/L		3	
Lannate	methomyl	i	SC	215 g/L		2	
lindane	Lindane	i	WP	25%		2	
Lindane	lindane	i	WP	25%		2	
Loredo	glyphosate	h	Sn	356 g/L	2.81	3	B
Lorsban	chlorpyrifos	i	EC, WP	480 g/L, 50%		2	
Malathion	malathion	i	EC	500 g/L		3	
malathion	Malathion	i	EC	500 g/L		3	
mancozeb	Dithane	f	WP, Gr	80%, 75%		3	
metalaxyl	Ridomil Gold	f	EC	480 g/L		2	
metam sodium	Vapam	ifnh	Sn	380 g/L	2.63	3	C
methomyl	Lannate	i	SC	215 g/L		2	
napropamide	Devrinol DF	h	DF	50%	2	3	C
Orthene	acephate	i	SP	75%		2	C
permethrin	Pounce	i	EC	384 g/L		3	
Pfizol-10	fatty alcohol (n-decanol)	s	Li	688 g/L		3	
pirimicarb	Pirimor	i	WP	50%		2	

Table 1-5. Pesticides used in producing flue-cured tobacco

Common name cross-referenced with trade name examples[1]		Use[2]	Formulation[3]	Active ingredient	Conversion factor[4]	Schedule	Winter storage[5]
Pirimor	pirimicarb	i	WP	50%		2	
Pounce	permethrin	i	EC	384 g/L		3	
Pyrinex	chlorpyrifos	i	EC	480 g/L		2	
Renegade	glyphosate	h	Sn	356 g/L	2.81	3	B
Ridomil Gold	metalaxyl	f	EC	480 g/L		2	
Ripcord	cypermethrin	i	EC	400 g/L		2	
Roundup Transorb	glyphosate	h	Sn	360 g/L	2.78	6	B
Roundup	glyphosate	h	Sn	356 g/L	2.81	3	B
Sevin	carbaryl	i	WP, WP, Su	50%, 80%, 480 g/L		3	
Telone II	1,3-dichloropropene	n	Li	94%		2	
Telone C-17	1,3-dichloropropene + chloropicrin	ifn	Li	78% + 16.5%		2	
Thuricide	bacillus thuringiensis	i	Li	4,000 IU/mg		3	
Touchdown 480	glyphosate TMS	h	Sn	330 g/L	3.03	6	B
trichlorfon	Dylox	i	EC	420 g/L		3	
Vapam	metam sodium	ifnh	Sn	380 g/L	2.63	3	C
Venture L	fluazifop-p-butyl	h	EC	125 g/L	8	5	C
Vorlex Plus	1,3-dichloropropene + methyl isothiocyanate	ifnh	Li	40% + 20%	1.74	2	B
Vorlex Plus CP	1,3-dichloropropene + methyl isothiocyanate + chloropicrin	ifnh	Li	34% + 17% + 15%	1.39	2	B
Wrangler	glyphosate	h	Sn	356 g/L	2.81	3	B

1.Trade names start with a capital letter.Mention of a brand or trade name is not a guarantee of the product by the Ontario Weed Committee or the Ontario Crop Protection Committee. Neither does this use signify that these products are approved to the exclusion of comparable products.
2. i – insecticide, f – fungicide, h – herbicide, n – nematicide, s – sucker control
3. EC – emulsifiable concentrate, DF – dry flowable, Gr – granular, Li – liquid, SC – soluble concentrate, Sn – solution, SP – soluble powder, Su – suspension (flowable) , WP – wettable powder.
4. See page 16 for information on how to use the conversion factor.
5. See page 1 for information on Pesticide Schedules in Ontario.
6.A – Do not allow to freeze. B – Preferably should not freeze. If frozen, return to original state by allowing product to warm to 10°C–20°C and agitate thoroughly before use. C – Not usually damaged by freezing. Store in a cool, dry place.

Conversion factor for herbicides

Multiply recommended amount of active ingredient in *Table 1-5. Pesticides used in producing flue-cured tobacco* by the conversion factor to get the amount of product to use.

Dry materials example:

To apply 2.25 kg/ha napropamide to control germinating annual weeds in flue-cured tobacco:

Devrinol DF (50% active) 2.25 x 2 = 4.5 kg/ha (product).

To apply in 30 cm band over tobacco transplants, spaced on rows 107 cm apart, multiply broadcast product rate by band width divided by row width, 4.5 x 30÷107 = 1.26 kg/ha or 0.5 kg/ac (product).

Liquid or flowable example:

To apply 0.125 kg/ha fluazifop-p-butyl to control emerged annual grasses in flue-cured tobacco:

Venture L (125 g/L active) 0.125 x 8 = 1 L/ha (product).

To apply in 30 cm band over tobacco plants, spaced on rows 107 cm apart, multiply broadcast product rate by band width divided by row width, 1 x 30÷ 107 = 0.28 L/ha or 0.1 L/ac (product).

Interval before rainfall for post-emergent herbicides

Rainfall shortly after application of a post-emergent herbicide may reduce the weed control. This effect varies with the length of time and the drying conditions between application and rainfall,

the product, and the formulation, as well as with the amount, intensity and duration of the rain.

The following intervals are based on label information and additional details supplied by the chemical industry:

2 hours	Venture L, Fusilade II
4 hours	Roundup Transorb
6 hours	Roundup, Touchdown

For more information, contact the manufacturer. In the case of a tank mix, use the longest time interval of the products being considered.

2. Soil Management and Fertilizer Use

Proper fertilization plays an essential part in maintaining maximum yields of high-quality tobacco.

The analysis of fertilizer and rates of application vary with the type of tobacco and soil. Effective use of fertilizers is related to soil fertility and management, soil organic matter, manure application, soil acidity, cultural methods, incidence of disease and variety of tobacco. Commercial fertilizers supplement and balance the plant food in the soil. Suitable crop rotations and cover crops supply organic matter that reduces leaching of plant nutrients and lessens soil erosion.

Recommendations in this publication refer to flue-cured tobacco unless otherwise indicated.

The *Fertilizers Act*

This Act regulates and controls agricultural fertilizers and is administered by the Canadian Food Inspection Agency of Agriculture and Agri-Food Canada.

Standards for fertilizers used on tobacco

There are recommended standards for the forms of nitrogen and the amounts of chloride and magnesium in tobacco fertilizers.

Nitrogen

At least 1/4 of the total nitrogen should be in the nitrate form. The exception is side-dressing fertilizer, in which at least 1/2 of the nitrogen should be in the nitrate form.

Chloride

The level of chloride must be controlled within narrow limits because of its effect on seedling growth and on the burn and moisture-holding capacity of the cured leaf. A high chloride level in the cured leaf lowers the burning quality and causes excessive moisture uptake by the leaf. Excess chloride in the seedbed may be toxic to young seedlings and contribute to damage from soluble salts.

The special tobacco seedbed fertilizer 4-30-8 should contain no more than 1.25% chloride.

In the field, the total amount of chloride applied through fertilizer should not exceed 23 kg/ha. The major portion of the chloride should be applied at the time of transplanting with only a minimal amount applied after.

Magnesium

The special tobacco seedbed fertilizer 4-30-8 should contain a minimum of 2% water-soluble magnesium.

Micronutrients

According to regulations under the *Fertilizers Act*, each fertilizer to which micronutrients have been intentionally added must have a label guarantee. The label must show the amount of each micronutrient, stated in per cent on an elemental basis.

Soil testing

OMAF-accredited soil tests are the most accurate tool available to Ontario farmers for determining how much phosphorus, potassium and magnesium fertilizers and lime should be applied. *Table 2-1. OMAF-accredited soil tests* on page 19 lists the materials and nutrients analyzed.

The OMAF-recommended fertilizer rates in this publication are designed to produce the highest economic yields when accompanied by good or above average management. Research shows that higher rates occasionally produce higher yields, but these increases in yield are likely to be small and not profitable. Some fertilizer is recommended at soil test levels slightly above those where crop response is profitable. This is done to maintain high soil nutrient levels and to allow for some error in sampling the field. For high value crops such as

Table 2-1. OMAF-accredited soil tests

Materials analyzed	What is analyzed[1]
Soils for field crops, commercial turf, etc.	Plant-available phosphorus, potassium, magnesium, manganese, zinc, pH, lime requirement
Greenhouse media	Plant-available nitrogen, phosphorus, potassium, calcium, magnesium, pH, total salts
Nutrient solutions, water	Plant-available nitrogen, phosphorus, potassium, calcium, magnesium, pH, total salts, sulphates, chlorides

1 Soil organic matter can be useful for herbicide recommendations but is not an accredited test.

tobacco, the maximum profit we aim for requires essentially the same amount of fertilizer as maximum crop value (maximum yield with high quality).

Be sure that any testing service you use is accredited. To be accredited, a laboratory must use OMAF-approved testing procedures and demonstrate acceptable analytical precision and accuracy. Refer to *Table 2-2. Accredited soil test labs in Ontario* for a list.

Each year farmers ask OMAF staff to interpret results from unaccredited laboratories. Provided the laboratory uses the identical test used by the OMAF-accredited service and expresses their test results in the same units, the OMAF fertilizer requirements for phosphate and potash can be determined although there is no assurance of how accurate the analysis is.

A number of labs provide soil tests not accredited by OMAF, such as exchange capacity, aluminium and copper. These are not accredited because they have not been found to contribute to better fertilizer recommendations. Research has shown that on Ontario soils the use of exchange capacity to adjust potash recommendations can lead to less reliable recommendations than are now provided.

Soil sampling

Soils may be sampled with a sampling tube or a shovel. Sample each field or uniform section of a field separately. Take at least 20 soil cores 15 cm deep from any field or area sampled up to 5 ha in size. For fields larger than 5 ha, take proportionately more cores. The more cores taken, the more likely the soil sample will provide a reliable measure of the fertility in the field. One sample should not represent more than 10 ha.

Table 2-2. Accredited soil test labs in Ontario

Labratory name	Address	Telephone/Fax	Web site/E-mail	Contact
A & L Canada Laboratories East, Inc	2136 Jetstream Road London, Ont. N5V 3P5	tel: (519) 457-2575 fax: (519) 457-2664	www.al-labs-can.com aginfo@al-labs-can.com	Greg Patterson Ian McLachlin
Accutest Laboratories	146 Colonnade Road, Unit 8 Nepean, Ont. K2E 7Y1	tel: (613) 727-5692 fax:(613) 727-5222	www.accutestlabs.com phaulena@accutestlabs.com	Lorna Wilson Peter Haulena
Agri-Food Laboratories	503 Imperial Road, Unit 1 Guelph, Ont. N1H 6T9	tel: (519) 837-1600 1-800-265-7175 fax:(519) 837-1242	www.agtest.com lab@agtest.com	Dale Cowan Nora Wilson
Brookside Laboratories, Inc.	301 South Main Street New Knoxville, Ohio 45871	tel: (419) 753-2448 fax: (419) 753-2949	nfisher@blinc.com	Nicole Fiisher Mark Flock
Soil and Nutrient Laboratory (formerly Analytical Services, Land Resource Science)	University of Guelph P.O. Box 3650, 95 Stone Road West Guelph, Ont. N1H 2W1	tel:(519) 767-6226 fax: (519) 767-6240	vkerslak@lsd.uoguelph.ca	Virginia Kerslake
Stratford Agri Analysis (A Daco Laboratories Ltd. company)	1131 Erie St., Box 760 Stratford, Ont. N5A 6W1	tel: (519) 273-4411 1-800-323-9089 fax: (519) 273-4411	www.stratfordagri.com saa@dacolabs.com	Dale Peters Keith Lemp

These labs are accredited to perform soil tests for pH, buffer pH, P, K, Mg and Nitrate-N on Ontario soils.
There is no official accreditation in Ontario for tissue analysis, but these labs are monitored for proficiency on tissue analyses.

Traverse the sampling area in a zigzag pattern to provide a uniform distribution of sampling sites. Sample separately parts of a field that differ in soil or crop appearance or in previous fertilization, manuring or liming, even if they are too small to fertilize separately. Avoid sampling recent fertilizer bands, dead furrows, areas adjacent to gravel roads, or where lime, manure, compost or crop residues are piled.

Collect the soil in a clean pail, break up the lumps and mix the soil well. Take a subsample from the soil in the pail and place it in a soil sample box. Send the soil sample box for testing.

When to sample

To provide dependable recommendations, fields should be tested before each tobacco crop, preferably in the fall. Potash levels can change quickly where large amounts of nutrients are removed from sandy soils (for example with crops such as alfalfa hay, corn silage, potatoes or tomatoes) and are not returned. Under these conditions take samples every year.

Information sheets

Management practices that affect a soil test recommendation are manure application, legume sod ploughed down and the crop to be fertilized. This information is essential for a reliable fertilizer recommendation and should be recorded on the field information sheet that must accompany the soil sample sent in for analysis.

Other methods of assessing nutrient needs

The OMAF-accredited soil testing program is the main guide, along with help from plant analysis and nutrient deficiency symptoms, for determining your specific fertilizer requirements.

Plant analysis is the main tool used for tree fruits and can serve as additional information supporting the soil test for field and vegetable crops.

Nutrient deficiency symptoms on crop leaves are helpful in some cases but have serious drawbacks in others, particularly with potassium and phosphorus.

It is occasionally suggested that a farmer apply the amounts of nutrients removed by the crop. This has some application for nitrogen, as with some crops the suggested rate approximates what the plant removes. It has little relevance for other nutrients in Ontario. Some of our clay and clay loam soils have sufficient potassium to last many years. Application of potassium each year on these soils is a waste of money and ignores one of the few advantages that clay soils have over coarser-textured soils.

Field fertilization

Fertilizer and lime requirements for tobacco should be determined by using an accredited soil test along with information on soil type, past management and yield, and quality of tobacco usually produced on the field.

Nitrogen

Under Ontario conditions, a sufficiently reliable test for nitrogen does not exist for tobacco. Since the amount of nitrogen available from organic matter varies from season to season, depending on rainfall and temperature, it is extremely difficult to determine the optimum amount to apply. Adjustments in the direct-fertilizer application of nitrogen may help but cannot completely correct a problem of too much or too little nitrogen in the soil. The use of nitrogen on the previous rye or wheat crop and the application of manure are just as important as the amount of nitrogen applied to the tobacco crop.

Previous tobacco crops usually provide the most reliable basis for determining the nitrogen requirement. Keep a yearly record of each field to get an accurate picture of maturity, size, quality, and yield. The amount of nitrogen applied to previous tobacco crops can then be used as a guide. An adjustment of at least 4 kg/ha of nitrogen at transplanting is usually required to make any significant change in the crop. Application of nitrogen rates in excess of recommendations, and nitrogen applied after the last cultivation, can result in undesirable leaf quality, especially in the upper leaves.

Phosphate and potash

Use the recommendations in Table 2-3 on page 21 only with OMAF-accredited soil tests. After deciding on the amount of nitrogen you want to apply, choose the analysis of fertilizer or custom blend that most closely fits the phosphate and potash requirements indicated by your soil test.

Where more than 180 kg of phosphate and 220 kg of potash are required, avoid salt problems by applying the additional amounts as a separate

Table 2-3. Phosphate and potash requirements based on OMAF-accredited soil tests

Sodium bicarbonate phosphorus soil test		Phosphate (P_2O_5) required	Ammonium acetate potassium soil test		Potash (K_2O) required
mg/L	rating	kg/ha	mg/L	rating	kg/ha
0–3		260	0–15		270
4–5		250	16–30		260
6–7	low	240	31–45	low	240
8–9		230	46–60		220
10–12		220	61–80		190
13–15		210	81–100		170
16–20		200	101–120		150
21–25		180	121–150		140
26–30	medium	160	151–180	medium	130
31–40		140	181–210		120
41–50		110	211–250	high	110
51–60	high	80	250+	very high	100
61–80		50			
80+	very high	20			

application rather than in bands at planting time. Phosphate is most effective if applied before or at planting.

Magnesium

For tobacco, additional magnesium is required only in the few instances where the soil test value falls below 30. In these cases, if the pH is below 6.5 the most economic and long-term solution is an application of dolomitic limestone. If there is a limestone requirement, apply the indicated rate. Otherwise, 1 tonne/ha is recommended. Where the pH is 6.5 or above and the magnesium value from the soil test is below 30, apply 30 kg/ha of soluble magnesium. This could be mixed into the planting fertilizer or applied as a side-dressing.

Potassium competes with magnesium for uptake by crops, and potash applications can therefore induce or increase magnesium deficiency. For this reason, it is important to monitor soil potassium levels and to carefully control potash fertilizer applications on low magnesium soils.

Calcium

Calcium deficiency has not been a problem on Ontario soils with a soil pH adequate for field crop growth. Adequate soil pH is a reliable indicator of adequate calcium in the soil.

Fertilizer application

The total requirement for nitrogen and potassium may be applied at planting or split, with a portion applied through the planter and the rest side-dressed near the time of the last cultivation. Splitting the nitrogen application may reduce leaching losses and provide more flexibility in handling soil variations. It also gives you a chance to evaluate nitrogen requirements according to seasonal conditions.

At least 50% of the nitrogen should be applied at planting, with the remainder side-dressed near the time of the last cultivation. Avoid applying nitrogen after the last cultivation, as this can result in undesirable leaf quality, especially with the upper leaves.

The total phosphate requirement should be applied at the time of planting, except where the requirement exceeds 180 kg/ha. In this case a portion of the phosphate should be broadcast before planting. The inclusion of phosphate in side-dressing fertilizer is expensive, ineffective and unnecessary.

Table 2-4. Example of split fertilizer application for tobacco on page 22 shows an example where the requirements are estimated to be 36 kg/ha of nitrogen and, according to a soil test, 20 kg/ha of phosphate and 160 kg/ha of potash.

Leaching

Tobacco soils are subject to leaching throughout the season and are most vulnerable during the first 4-5 weeks after planting. Nitrogen is the nutrient of most concern although there may be some loss of chloride, potassium and magnesium.

Table 2-4. Example of split fertilizer application for tobacco

	Nutrient applied (kg/ha)		
	Nitrogen	Phosphate	Potash
3–4–18 at 600 kg/ha with planter	18	24	108
9–0–27 at 200 kg/ha side-dressed	18	0	54
Total	36	24	162

The required adjustment for nitrogen lost through leaching varies because of factors such as amount of rainfall, amount of fertilizer already applied, crops in rotation, fertility management, and soil texture and drainage.

Fertilizer placement

Fertilizer used at transplanting should be applied in bands 10 cm on each side of the row and level with, or slightly below, the root crown (8–10 cm deep). Be careful. Closer placement of fertilizer could result in root injury. Wider placement could delay early growth. Broadcasting a complete tobacco fertilizer is wasteful and may harm yield and quality if there is high rainfall or too much irrigation.

Planting water fertilizers

Fertilizers in the planting water are not recommended. These fertilizers in combination with certain insecticides in the planting water may injure newly transplanted plants, causing death or stunting. See "Seed maggots" on page 58.

Foliage feeding

Although the tobacco plant can absorb certain nutrients in small amounts through its leaves, spraying fertilizer onto the leaves is an impractical method of correcting nitrogen, phosphorus or potassium deficiency. If more of these nutrients is required after transplanting, use a side-dress application.

Manure

Manure can be used as a source of organic matter and plant food, as shown in Table 2-5. The content of nitrogen (N), phosphate (P_2O_5) and potash (K_2O) in manure is extremely variable. If you can get a representative sample, a manure analysis will indicate more accurately than Table 2-5. the amounts of nutrients available for crop production from the manure you intend to use.

A manure analysis is available from several laboratories in Ontario. When sending a sample to the lab, fill a plastic jar (about 2 L capacity) half-full, cover, place in a plastic bag and store in a cool place until shipping. Analysis should include total nitrogen (N), ammonium-nitrogen (NH_4–N), phosphorus, potassium and dry matter. Ontario labs send back analysis results with percentages for nitrogen, phosphorus, potassium and dry matter as well as mg/kg (or ppm) of ammonium-nitrogen. Percentages for phosphorus and potassium from manure are converted to commercial phosphate (P_2O_5) and potash (K_2O) equivalents, and commercial fertilizer reductions are given.

Table 2-5. Average amounts of available nutrients for different types of manure

Manure[1]	Average dry matter (%)	Available N[2]	Available N[3]	Available P_2O_5[4]	Available K_2O[5]
Liquid		kg/1,000 L (lb/1,000 gal)			
Dairy	6.5	1.6 (16)	0.6 (6)	0.7 (7)	3.0 (30)
Hog	3.6	2.6 (26)	0.7 (7)	1.1 (11)	2.0 (20)
Poultry	8.0	6.1(61)	1.7 (17)	2.5 (25)	3.4 (34)
Solid		kg/tonne (lb/ton)			
Poultry	49	11.5 (21)	6.0 (12)	9.0 (18)	12.5 (25)
Dairy	20	1.5 (3)	0.7 (1.4)	1.5 (3)	5.5 (11)
Beef	27	1.5 (3)	0.75 (1.5)	1.5 (3)	7.0 (14)

1 Nutrient values based on average analysis results for over 700 samples. There are large variations between different manures, so a manure analysis is your best guide to nutrient availability.
2 Nitrogen based on spring application, incorporated within 24 hours.
3 Nitrogen based on spring application, not incorporated (i.e. on soil surface for more than 7 days).
4 Phosphate from manure is assumed to be 40% as available as that in manufactured fertilizer in the year of application.
5 Potash from manure is assumed to be 90% as available as that in manufactured fertilizer in the year of application.

There are two nitrogen components in manure. Ammonium-nitrogen makes up the largest percentage of the nitrogen in liquid manure, with approximate percentages listed by livestock type in Table 2-6. The organic nitrogen component is available over time as the organic matter breaks down. About 30% of the organic nitrogen component of manure is assumed to be available to a growing crop. The percentage is generally higher in poultry and lower for ruminant manure.

Table 2-6. Approximate ammonium-nitrogen levels available by livestock type (expressed as % of total manure N)

Manure type	NH_4-N (%)
Liquid poultry	75
Liquid hog	62
Liquid beef	60
Liquid dairy	50
Solid hog	30
Solid poultry	30
Solid dairy	25
Solid beef	12

Ammonium-nitrogen is available immediately to a growing crop but is also most easily lost to volatilization unless incorporated soon after application. Soil moisture and weather conditions determine how quickly loss occurs and how much loss to expect. These losses are highest during sunny, high temperature days when soils are dry. Losses are lowest when conditions are overcast and cold, when soils are moist or during rainy periods. See *Table 2-7. Estimated per cent of ammonium-nitrogen lost to weather and soil conditions.*

Manure is not required on many tobacco farms where nitrogen is used during the spring and summer on the rye or wheat crop. However, sandy tobacco soils, particularly sandy knolls, usually benefit from an application of 12–18 tonnes/ha of cattle or swine manure. As shown in *Table 2-5. Average amounts of available nutrients for different types of manure* on page 22, poultry manure is high in nitrogen and is generally not recommended.

The use of manure on soils high in fertility is likely to delay tobacco maturity and lower quality.

Table 2-7. Estimated per cent of ammonium-nitrogen lost to weather and soil conditions

	Cool (<10°C)		Warm (>25°C)	
Days after application	**Wet**	**Dry**	**Wet**	**Dry**
Injected in season	0	0	0	0
Incorporated within 1 day	10	15	25	50
Incorporated within 2 days	13	19	31	57
Incorporated within 3 days	15	22	38	65
Incorporated within 4 days	17	26	44	73
Incorporated within 5 days	20	30	50	80
Not incorporated spring/summer/early fall				
Bare soil	40	50	75	90
Crop residue	30	35	60	70
Standing crop	20	25	40	50
Late fall (air temp < 10°)	25	25	N/A	N/A

Adapted: Beauchamp, University of Guelph,1995

Rotations

Rye

In a 2-year rotation with tobacco, rye has generally proven to be better than wheat for maintaining or increasing the amount of organic matter in the soil. Wheat is more subject to winterkill, and factors such as fall seeding date, nutrient shortage and pH are much more critical. For example, wheat can be seriously affected in certain fields by a shortage of manganese, while in the same fields tobacco and rye grow normally. Wheat may be substituted for rye where fertility is high, especially in soils with a sandy loam texture. Wheat is unlikely to produce enough crop residue on medium- to coarse-textured soils.

Nitrogen recommendations for rye grown in rotation with tobacco are shown in *Table 2-8. Fertilization of rye* on page 24.

Nitrogen should not be used in spring in fields where tobacco is oversized and matures late or in loamy sand to sandy loam soils where the field has been out of tobacco for more than 1 year. Under low fertility conditions you may exceed the rates in Table 2-8, but caution is advised as to amounts applied to crop residues.

Less than 25 kg of nitrogen should be applied in the summer to sandy loam soils where slow maturity has been experienced in the tobacco crop. Maturity of tobacco may be delayed if nitrogen is applied after mid-August or at a high rate.

Table 2-8. Fertilization of rye

	Nitrogen (kg/ha)	Examples
Apply in early spring when growth starts		
Sand	45	Ammonium nitrate (33-34% N) at 135 kg/ha or urea (45-46% N) at 100 kg/ha
Loamy sand	35	Ammonium nitrate at 105 kg/ha or urea at 80 kg/ha
Sandy loam	25	Ammonium nitrate at 75 kg/ha or urea at 55 kg/ha
Apply in summer on crop residues when grain is harvested		
	25–30	Ammonium nitrate at 75-90 kg/ha or urea at 60-65 kg/ha

Wheat

Generally, wheat should be fertilized in the spring with double the nitrogen rates recommended for rye in Table 2-8. Rates should be reduced by 1/2 in fields where tobacco is oversized and matures late or in medium to heavy soils where the field has been out of tobacco for more than 1 year.

For crop residues, apply the same rate of nitrogen as indicated for rye, following the precautions noted in the section on rye on page 23.

Plant analysis

Plant analysis measures the nutrient content of plant tissue. Comparing the results against the normal and critical values for tobacco, as shown in *Table 2-9. Interpretation of plant analysis for tobacco*, can indicate whether the nutrient supply is adequate for optimum growth.

Plant analysis, which is independent of soil testing, can help evaluate the fertility status of the tobacco crop. It can provide a valuable second opinion, especially for phosphorus, potassium, magnesium and manganese. It has not been reliable for nitrogen and zinc. Since there is no reliable soil test for boron and copper, plant analysis and visual symptoms are the only ways to diagnose deficiencies.

Plant analysis has limitations. Since it does not always indicate the cause of a deficiency or the amount of fertilizer required to correct it, expert help in interpreting the results is often needed.

Sampling

The time of sampling has a major effect on the results, since nutrient levels within a plant vary considerably with the age of the plant. Results are difficult to interpret if samples are taken at times other than those recommended.

Table 2-9. Interpretation of plant analysis for tobacco

	Green tissue (10th leaf at topping)		
	Normal range[1] in Ontario tobacco	Critical level[2]	Cured tissue (mid-stalk) normal value[3]
Nitrogen (N)	2.0–2.75%	1.5%	2.16%
Phosphorus (P)	0.15–0.25%	0.12%	0.28%
Potassium (K)	1.80–2.0%	1.4%	2.21%
Magnesium (Mg)	0.3–0.5%	0.2%	0.44%
Calcium (Ca)	1.5–2.5%	1.2%	2.09%
Sulphur (S)	0.45–0.6%	0.3%	–
Chloride (Cl)	0.3–0.8%	0.1%	0.66%
Boron (B)	20–35 ppm	10 ppm	32 ppm
Copper (Cu)	5–20 ppm	3 ppm	5.40 ppm
Iron (Fe)	200–800 ppm	50 ppm	194 ppm
Manganese (Mn)	40–150 ppm	20 ppm	134 ppm
Zinc (Zn)	30–60 ppm	20 ppm	40 ppm
Molybdenum (Mo)	3–6 ppm	1 ppm	1.12 ppm

1 Normal range – Within this range normal plant growth should occur.
2 Critical level – Crop response to added nutrients is not expected when values are above this level.
3 Normal value – Long-term average from the annual Ontario farm survey.

Sample tobacco during the week before topping. But, sample plants suspected of being nutrient-deficient as soon as a problem appears. Samples are best taken from a problem area rather than from the entire field.

Take samples from at least 30 plants distributed throughout the area. Each sample should consist of at least 100 g of fresh material taken from the middle stalk position, at about the tenth leaf, in 5 by 5 cm squares of tissue. Sample problem areas separately.

When taking samples, take care not to contaminate the sample with soil. Even a small amount causes the result to be invalid, especially for micronutrients.

Preparing samples

Samples of fresh plant material should be delivered directly to the lab. If they are not delivered immediately, dry them to prevent spoilage. You can dry the samples in an oven at 65°C or less or in the greenhouse, provided you take precautions to prevent contamination with dust or soil. Avoid contact of samples with galvanized (zinc plated) metal, brass or copper. Several Ontario labs do plant analysis.

Micronutrients

Additions of the micronutrients (boron, copper, iron, manganese, molybdenum, zinc) are generally not required for tobacco in Ontario. Surveys of tobacco soil and leaf tissue show that levels are usually adequate and in some cases excessive. Very high levels of iron, manganese and zinc are occasionally found in the cured leaf, and these are associated with a certain type of "grey" tobacco.

Testing for micronutrients

Before applying any micronutrient it is important to establish the need, since the range between beneficial and harmful amounts is narrow.

OMAF-accredited tests are available for manganese and zinc. Requirements for manganese and zinc by various crops, based on an OMAF-accredited soil test, are identified in *Table 2-10. Manganese requirements* and *Table 2-11. Zinc requirements*. In the case of zinc on corn, the soil test is best used along with visual deficiency symptoms. With manganese, plant analysis, visual symptoms and the soil test are all useful.

Table 2-10. Manganese requirements

Manganese Index [1]	Oats, wheat, barley, triticale, soybeans, onions, lettuce, beets Mn required[2] - kg/ha	Other crops
0–7	2	*
8–15	2	0
16– 50	0	0
50 + above normal	0	0

1 Manganese index reported = 498 + 0.248 (phosphoric acid extractable Mn in mg/L of soil) –137 soil pH + 9.64 (soil pH)^2.
2 Manganese should be applied as a foliar spray of manganese sulphate. Soil applications are inefficient.
* Manganese deficiency is not expected, even at this low soil test value, but if symptoms should appear treat as indicated under "Preventing and correcting manganese deficiency." Manganese deficiency has not been diagnosed on tobacco in Ontario.

Table 2-11. Zinc requirements

Zinc index [1]	Corn, onions Zn required[2]-kg/ha	Other crops
0–7	4	*
8–14	4	0
15–100	0	0
100 + above normal	0	0

1 Zinc index reported = 203 + 4.5 (DTPA extractable soil zinc in mg/L of soil) – 50.7 soil pH + 3.33 (soil pH)^2.
2 Foliar applications of zinc may be used in place of, or with soil applications, but reduce rate/ha. Foliar applications are preferred for fruit crops.
* Zinc deficiency is not expected, even at this low soil test value, but, if symptoms appear, a zinc spray may be applied to the crop. Zinc deficiency has not been diagnosed on tobacco, rye or wheat in Ontario.

OMAF-accredited tests are not available for boron, copper, iron, or molybdenum. Plant analysis is generally a better indicator of deficiencies of these nutrients. See "Plant analysis" on page 24.

Take great care to prevent contaminating soil samples with micronutrients, particularly zinc. Do not use galvanized (zinc plated) soil sampling tubes to take soil samples for micronutrient tests. Do not use metal containers to collect and mix samples. Clean plastic containers in good condition should be satisfactory. Soil samples that have been in contact with galvanized surfaces are unsatisfactory for zinc soil tests. Be careful to keep dust (from buildings, etc.) out of the samples.

Micronutrient deficiencies frequently occur in small patches in fields. Take soil or plant samples from problem areas separately, as samples taken from the entire field are unlikely to find the problem.

Preventing and correcting manganese deficiency

Manganese is less available at high soil pH, so it is important to add only as much lime as needed to correct soil acidity. Correct the deficiency as soon as detected by spraying the foliage with 2 kg of manganese per ha from manganese sulphate (8 kg/ha of manganese sulphate) mixed in 200 L of water. A "spreader-sticker" in the spray is recommended. If the deficiency is severe, a second spray may be beneficial. Soil applications of manganese are inefficient and not recommended. See OMAF Factsheet *Manganese in Soybeans and Small Grain Production*, Order No. 86-078.

Preventing and correcting zinc deficiency

High phosphorus in the soil or fertilizer can cause or increase the severity of zinc deficiency. Apply only the recommended amount of phosphorus. Use of animal manures can prevent or reduce zinc deficiency. Erosion control can prevent deficiency by maintaining the top soil.

Zinc deficiency can be prevented by applying zinc fertilizer to the soil. Foliar sprays can be useful to correct a deficiency after symptoms have appeared, provided this is done early in the growing season.

When zinc is required, it may be applied to the soil mixed in the fertilizer at rates supplying 4–14 kg/ha of zinc. The higher rate should be sufficient for up to 3 years. Not more than 4 kg/ha of zinc should be banded at planting. Zinc may be applied as a foliar spray at rates supplying 60 g zinc/100 L (0.6 lb/100 gal). A wetting agent should be added. Spray to leaf wetness. See also OMAF Factsheet *Zinc Requirements for Field Crops*, Order No. 83-089.

Copper

Copper soil tests are unreliable for Ontario soils, but plant analysis is useful. Copper is unlikely to be deficient on mineral soil, except perhaps on very sandy soils. Copper deficiency does occur on organic soils and is best diagnosed by plant analysis. When organic soils are first brought into cultivation, copper should be applied to the soil at 14 kg/ha copper for each of the first 3 years.

Boron

Boron deficiency usually occurs in dry weather so that response is erratic. Thus it has not been possible to develop a reliable soil test. Plant analysis is useful in predicting boron requirements, as are symptoms on the plants.

Take extreme care when using boron. Very small amounts are needed and an overdose is toxic. Boron deficiency has not been diagnosed on tobacco, cereals, peas and beans in Ontario. Boron applications to these crops or other crops in the year preceding them can be toxic. Boron should not be banded.

Iron and molybdenum

Iron and molybdenum have not been found to be deficient in Ontario field crops.

Soil acidity and liming

The pH scale, ranging from 0–14, indicates acidity and alkalinity. A pH value of 7.0 is neutral; values below 7.0 are acidic and those above 7.0 are alkaline. Most field crops grow well in a soil pH range from 6.0–8.0.

The need for limestone is determined by testing the soil to find the reaction (pH). On tobacco soils the most reliable indicator of pH is obtained from late fall or early spring sampling. The soil pH for tobacco should be above 5.5. Wheat, often grown in rotation with tobacco, is favoured by a pH of 6.0 or slightly higher.

To correct soil acidity, broadcast ground limestone and work it into the soil at rates determined by a soil test. *Table 2-12. Soil pH at which lime is recommended for crops* on page 27 shows the soil pH values below which lime is recommended and the "target" soil pH to which soils should be limed for different crops. In Ontario, most crops grow quite well at pH values above the target pH. However, in tobacco production excessive use of limestone to raise the pH above 6.5 may decrease the availability of certain micronutrients and create conditions favourable for developing black root rot.

The buffer pH

Different soils require different amounts of lime to bring their pH to a desired level. The amount required depends chiefly on the soil's clay and organic matter content. The soil pH is used to determine which soils need to be limed. A separate soil test, the buffer pH, is run on soils needing lime to determine the amount they require. Use *Table 2-13. Lime requirements to correct soil acidity based on soil pH and soil buffer pH* to determine the amount of lime required to reach the "target" soil pH values required for different crops.

Table 2-12.Soil pH at which lime is recommended for crops

Crops	Soil pH below which lime is recommended	Target soil pH*
Coarse and medium-textured mineral soils (sands, sandy loams, loams, and silt loams)		
All crops not listed below	6.1	6.5
Tobacco, corn, soybeans, winter rye, grass hay and pasture, turf, established tree fruits, grapes	5.6	6.0
Potatoes	5.1	5.5
Blueberry, cranberry, rhododendron, azalea	No lime recommended	
Fine-textured mineral soils (clays and clay loams)		
Alfalfa, cole crops, rutabagas	6.1	6.5
All crops not listed above or below	5.6	6.0
Tobacco, corn, rye, grass hay and pasture, established tree fruits, grapes	5.1	5.5
Blueberry, cranberry, rhododendron, azalea	No lime recommended	
Organic soils (peat and mucks)		
All crops not listed below	5.1	5.5
Blueberry, cranberry, rhododendron, azalea	No lime recommended	

*Where a crop is grown in rotation with other crops needing a higher pH (for example, corn in rotation with wheat or alfalfa), the soil should be limed to the higher pH.

Table 2-13. Lime requirements to correct soil acidity based on soil pH and soil buffer pH

Buffer pH	Target soil pH = 7.0*	Target soil pH = 6.5 (Lime if soil pH <6.1)	Target soil pH = 6.0 (Lime if soil pH <5.6)	Target soil pH = 5.5 (Lime if soil pH <5.1)
Ground limestone required – t/ha based on an Agricultural Index of 75				
7.0	2	2	1	1
6.9	3	2	1	1
6.8	3	2	1	1
6.7	4	2	2	1
6.6	5	3	2	1
6.5	6	3	2	1
6.4	7	4	3	2
6.3	8	5	3	2
6.2	10	6	4	2
6.1	11	7	5	2
6.0	13	9	6	3
5.9	14	10	7	4
5.8	16	12	8	4
5.7	18	13	9	5
5.6	20	15	11	6
5.5	20	17	12	8
5.4	20	19	14	9
5.3	20	20	15	10
5.2	20	20	17	11
5.1	20	20	19	13
5.0	20	20	20	15
4.9	20	20	20	16
4.8	20	20	20	18
4.7	20	20	20	20
4.6	20	20	20	20

*Liming to pH 7.0 is recommended only for club-root control on cole crops.

Limestone quality

Two main factors affect the value of limestone for soil application.

One is the amount of acid a given quantity of limestone neutralizes when totally dissolved. This is called the neutralizing value and is expressed as a percentage of the neutralizing value of pure calcium carbonate. A limestone that neutralizes 90% as much acid as pure calcium carbonate is said to have a neutralizing value of 90. In general, the higher the calcium and magnesium content of a limestone, the higher the neutralizing value.

The second factor is particle size. Limestone rock has much less surface area to react with acidic soil than finely powdered limestone and neutralizes acidity too slowly to be of much value. The calculation of a fineness rating for ground limestone is illustrated in *Table 2-14. Example calculation of the fineness rating of a limestone.*

Table 2-14. Example calculation of the fineness rating of a limestone

Particle size	% of sample	X	Effectiveness factor	=	Fineness rating
Coarser than no. 10 sieve[1]	10	X	0	=	0
No. 10 to no. 60 sieve	40	X	0.4	=	16
Passes through no. 60 sieve	50	X	1.0	=	50
Fineness rating of whole sample					**66**

1 A no. 10 Tyler sieve has wires spaced 2.0 mm apart and a no. 60 Tyler sieve has wires 0.25 mm apart.

The Agricultural Index

Some means of combining the neutralizing value and the fineness rating is needed to compare available limestones. This is the Agricultural Index.

The Agricultural Index can be used to compare the relative value of different limestones for neutralizing soil acidity. Lime with a high Agricultural Index is worth proportionately more than lime with a low index because it may be applied at a lower rate. If two ground limestones, A and B, have Agricultural Indices of 50 and 80 respectively, the rate of application of limestone A required for a particular soil will be 80/50 x the rate required for limestone B. Limestone A spread on your farm is worth 50/80 x the price per tonne of limestone B.

$$\text{Agricultural Index} = \frac{\text{neutralizing value X fineness rating}}{100}$$

Recommendations from OMAF-accredited soil tests are based on limestone with an Agricultural Index of 75. If you know the Agricultural Index you can calculate a rate of application for limestone of that quality. Take the limestone application rate from the soil test report, multiply it by 75 and divide by the Agricultural Index of your limestone to get its application rate.

For example, if you have a limestone requirement by soil test of 9 t/ha, and your most suitable source of limestone has an Agricultural Index of 90, you should apply 9 x 75/90 = 7.5 t/ha.

The Agricultural Index does not provide information about magnesium content. Dolomitic limestone should be used on soils low in magnesium.

Calculating rate of application of limestone

$$\text{limestone application rate from soil test report} \times \frac{75}{\text{Agricultural Index of your limestone}} = \text{application rate of your limestone}$$

Limestone materials

Calcitic limestone consists largely of calcium carbonate. Dolomitic limestone is a mixture of calcium and magnesium carbonates. Dolomitic limestone should be used on soils with a magnesium soil test of 100 or less, as it is an excellent, inexpensive source of magnesium for acid soils. On soils with magnesium tests greater than 100, use either calcitic or dolomitic limestone.

Tillage depth

Lime recommendations presented here should raise the pH of the top 15 cm (6 in.) of a soil to the listed target pH. If the soil is ploughed to a greater depth than 15 cm, proportionately more lime is needed to reach the same target pH. Where reduced tillage depths are used rates of application should be reduced proportionately. More frequent liming will be needed.

Lowering soil pH

On soils with pH values below 6.5, it is possible to lower the pH (make the soil more acidic) by adding sulphur or ammonium sulphate. This may be desirable for some crops (for example, potatoes for scab control), but usually is not suitable for rotation crops. pH can not be made to flip flop from a low

pH to a more moderate pH year to year. If the soil pH is above 6.5, it is inadvisable and quite impractical to lower the soil pH because of the large amounts of sulphur or ammonium sulphate required.

Calibrating tobacco fertilizer applicators

A fertilizer applicator should be calibrated periodically to ensure application at the desired rate. The amount of fertilizer per plant depends on the plant spacing and application rate as shown in *Table 2-15. Fertilizer calibration*. For example, when applying 1,000 kg/ha of fertilizer and using a plant spacing of 61 x 107 cm (24 x 42 in.) 25 kg fertilizes 383 plants.

When calibrating an applicator first place and level about 15 kg of fertilizer in the hopper and mark this level. Then put in 25 kg of fertilizer. To avoid packing, which causes poor calibration, do not place the fertilizer in the hopper until immediately before transplanting. Plant the desired number of plants as shown in Table 2-15. and check the level in the hopper. If the fertilizer is above the mark, too little is being applied. If it's below the mark, too much is being applied. This method gives a fairly accurate calibration of the rate of application, but you should also check the fertilizer on a hectare and field basis.

Table 2-15. Fertilizer calibration

Plant spacing		Plant population		Plants per 25 kg (55.1 lb) of fertilizer											
				kg/ha of fertilizer											
				600	700	800	900	1000	1100	1200	1400	1600	1800	2000	2200
				lbs/ac of fertilizer											
cm	in.	ha	ac	540	630	720	810	900	990	1080	1260	1440	1620	1800	1980
56x102	22x40	17,613	7,128	730	625	547	486	438	398	365	313	274	243	219	199
58x102	23x40	16,848	6,818	705	604	528	469	423	384	352	302	264	235	211	192
61x102	24x40	16,146	6,534	670	574	502	446	402	365	335	287	251	223	201	183
53x107	21x42	17,574	7,112	735	630	551	490	441	401	367	315	276	245	220	200
56x107	22x42	16,776	6,789	696	596	522	463	417	379	348	298	261	232	209	190
58x107	23x42	16,045	6,493	672	575	504	447	403	366	336	288	252	224	201	183
61x107	24x42	15,377	6,223	639	547	479	425	383	348	319	274	239	213	192	174
66x107	26x42	14,194	5,744	590	506	443	393	354	322	295	253	221	197	177	161
51x117	20x46	16,848	6,818	699	599	524	465	419	381	349	299	262	233	209	190
56x117	22x46	15,316	6,198	636	545	477	424	382	347	318	273	239	212	191	173
51x122	20x48	16,146	6,534	670	574	502	446	402	365	335	287	251	223	201	183
41x102	16x40	24,219	9,801	–	–	–	–	–	–	–	427	374	332	299	272
46x102	18x40	21,528	8,712	–	–	–	–	–	–	–	381	333	296	266	242
41x107	16x42	23,065	9,334	–	–	–	–	–	–	–	408	357	317	285	259
46x107	18x42	20,502	8,297	–	–	–	–	–	–	–	363	317	282	254	231

Fertilizer materials

Table 2-16. Fertilizer materials—primary nutrients shows the percentage of fertilizer nutrient in different materials. Materials used to fertilize tobacco are limited by standards for forms of nitrogen and amounts of chloride and magnesium. See "Standards for fertilizers used on tobacco" on page 18.

For crops other than tobacco, refer to the appropriate crop recommendations publication for more information on selection, toxicities and safe rates. If soil or tissue tests show that secondary or micronutrients are needed, the most common sources are listed in *Table 2-17. Fertilizer materials—secondary and micronutrients*. In addition to these micronutrient sources, fertilizer companies have premixes available containing one or more micronutrients.

For more information on soil fertility, refer to OMAF publication, *Soil Fertility Handbook*, Order No. 611

Table 2-16. Fertilizer materials—primary nutrients

Nitrogen materials	Form	% Nitrogen (N)
Ammonium nitrate	dry	30–34
Urea	dry	45–46
Ammonium sulphate	dry	21
Urea-ammonium nitrate	liquid	28
Anhydrous ammonia	liquid[1]	82
Calcium ammonium nitrate	dry	27.5
Calcium nitrate	dry	15.5
Calcium nitrate	liquid	9
Phosphate materials		**% Phosphate (P_2O_5)**
Single superphosphate		20
Triple superphosphate		44–46
Monoammonium phosphate		48–52
Diammonium phosphate (18-46-0)		46
Potash materials		**% Potash (K_2O)**
Muriate of potash		60–62
Sulphate of potash		50
Sulphate of potash magnesia (11% Mg)		22
Potassium nitrate (13-0-44)		44

1 Liquid under pressure

Table 2-17. Fertilizer materials—secondary and micronutrients

Magnesium materials	%Magnesium (Mg)
Dolomitic limestone	6–13
Epsom salts (magnesium sulphate)	10.5
Sulphate of potash magnesia	11
Boron materials	**% Boron (B)**
Sodium borate	12–21
Solubor	20.5
Copper materials	**% Copper (Cu)**
Copper sulphate	13–25
Copper chelates	5–13
Manganese materials	**% Manganese (Mn)**
Manganese sulphate	26–28
Molybdenum materials	**% Molybdenum (Mo)**
Sodium molybdate	39
Zinc materials	**% Zinc (Zn)**
Zinc sulphate	36
Zinc chelates	7–14
Zinc oxysulfate	18–36

Water quality

A clean and abundant supply of water is critical to the success of your farm business and the health of your family. Water is also shared by others, including fish and wildlife. You have a right to expect an ample supply of clean water and a responsibility to make sure the water leaving your farm is abundant and clean for the next user.

Farm operations affect water quality in many ways. Surface water quality can be affected by soil erosion, manures, septic system effluent, milkhouse wastes, pesticides and fuels. Groundwater quality can be affected by nutrients, manures, pesticides and fuels moving down through the soil into the groundwater.

The greatest water quality challenges for farmers involve bacteria (from manures), nitrates and sediment. Pesticide contamination is much less of a problem. The following practices will help correct or reduce these problems.

Bacterial contamination

- Contain run-off from manure storages, livestock yards, and silos.
- Avoid spreading manure on frozen or snow-covered ground.
- Make sure your well is properly maintained and is protected from surface contamination.
- Properly treat or store milkhouse waste water.
- Ensure that the domestic septic system is working properly and not discharging into a drainage system.

Soil erosion

- Adopt conservation tillage practices.
- Install erosion control structures.

Nitrate contamination

- Complete a nutrient management plan for your farm.
- Avoid spreading excessive amounts of manure or fertilizer on a field.

- Where a lot of manure and forages are used, use a nitrate soil test to help determine nitrogen requirements.

- Reduce nitrogen fertilizer when the previous crop was a legume or when manure was applied.

Pesticide contamination

- Store pesticides properly and keep as little as possible in storage.

- Stay away from ditches and other sources of water when spraying.

- Clean up spills quickly and thoroughly.

- Be careful not to mix up more pesticide than you require.

Fuel contamination

- Store fuel away from wells, ditches, etc.

- Use automatic shut off nozzles to prevent spills.

Nutrient Management Act information

The *Nutrient Management Act* received Royal Assent on June 27, 2002. Regulations are being drafted. For the most up-to-date information on this legislation, refer to the OMAF web site at www.omaf.gov.on.ca or phone the Agricultural Information Contact Centre at 1-877-424-1300.

OMAF resources

The following OMAF/Agriculture and Agri-Food Canada/Ontario Federation of Agriculture booklets contain more information on water quality problems and solutions, soil conservation measures and nutrient and manure use:

Best Management Practices - Water Management
Best Management Practices - Field Crop Production
Best Management Practices - Nutrient Management
Best Management Practices - Pesticide Storage, Handling and Application

3. Recommended Varieties

In recent years, more emphasis has been placed on breeding varieties of flue-cured tobacco that produce more mature styles of leaf and are better adapted to Canadian production conditions.

CT 144, CT 572, RG 17 and RG 81 are four new registered varieties. The Canadian Tobacco Research Foundation's breeding program developed CT 144 and CT 572 . RG 17 and RG 81 were developed and first registered in the United States. They have been tested in Canada and performed well. RG 17 and RG 81 have a 2-year restricted registration under the *Canada Seeds Act*, due to expire January 11, 2004.

The following variety descriptions and performance data in Table 3-1 on page 34 and Tables 3-2 and 3-3 on page 35 are from comparisons made at the Southern Crop Protection and Food Research Centre in Delhi. All varieties were grown in the same trial, using the same agronomic practices.

AC Cheng

Registered in 1994. Derived from crosses involving a somatic hybrid (*Nicotiana rustica* x *Nicotiana tabacum*), Candel and Delgold. Yield and grade index compare favourably with Delgold. AC Cheng has a more balanced grade type and cleaner styles. Typically, AC Cheng produces a higher percentage of "L" grades but lower percentage of "O&M" grades compared to Delgold and Delfield. Cherry red grades tend to be higher with AC Cheng than some other varieties. AC Cheng tops slightly later than Delgold and has one leaf less to harvest. Similar to Delgold, it has intermediate tolerance to black root rot and low ground sucker growth.

AC Gayed

Registered in 1995, this variety is a black root rot-resistant version of Delgold. The gene for resistance was transferred by repeated crossing to Delgold so that AC Gayed's performance would be similar to Delgold in black root rot-free soils. Where black root rot is a problem, AC Gayed performs very well. When comparing AC Gayed to CT 681, another variety immune to black root rot, CT 681 tends to produce a higher yield and grade index. However, AC Gayed's leaf size is generally smaller than CT 681, which should allow for easier handling. In trials where AC Gayed was grown in soils with high black root rot disease pressure, AC Gayed's yield and grade index performance were similar when grown with or without a multi-purpose fumigant. However, nematode control is still required if pressure from nematodes is high enough to warrant treatment. AC Gayed tends to top earlier and has fewer leaves than Delgold.

AC White

Registered in 1997. Developed using pedigree selection from a cross between 87 BL26-P1 and 86SM9-3. Early plant growth in the greenhouse is more compact with normal leaf number and stretches to reach a height similar to Delgold when ready for transplanting. In the field, plant style is cylindrical with leaf dimensions and plant height similar to Delgold. AC White tends to be more sensitive to nitrogen than some other varieties. Overfeeding can result in increased leaf size and later maturity. Total leaf number is similar to Delgold. AC White has variable tolerance to black root rot ranging from intermediate to high. Leaf yield and buyer ratings for AC White are typically higher than Delgold. Some growers comment that AC White appears more susceptible to Blue Mold than some other varieties.

CT 144

Registered in 2001. Derived from a cross between Canadian breeding line TB5-2 and American variety K326. CT144 tends to produce a higher yield than Delgold and Delfield. Typically, CT 144 tops 3 days later than Delgold and has 1–2 more leaves to harvest. CT 144 is slightly taller in plant height but similar in sucker weight to Delgold. CT 144 produces a similar percentage of "O" and more "L" grades than Delfield and Delgold. Brown spots in the bottom leaves were observed on wet years but

had no noticeable effect on yield and quality. CT 144 has exhibited good tolerance to black root rot. The company evaluations are higher for CT 144 than for Delgold.

CT157

Registered in 1999. It is a cross between Delgold and the U.S. variety K 326. Yield is lower, but grade index is higher than Delgold and Delfield. Typically, per cent "O&M" grades are higher and per cent "F&L" grades and off-grades are lower than Delgold and Delfield. Company ratings of the cured leaf tend to be higher than Delgold and Delfield. It takes about 3 days longer to topping than Delgold and Delfield. Plant height is slightly taller and leaves per plant are similar to Delgold and Delfield. CT 157 tends to produce a thinner-style leaf than other varieties. Black root rot tolerance is intermediate, similar to Delgold and Delfield.

CT 166

Registered in 1999. Derived from a cross between Delgold and Islangold, a variety that was grown in PEI. Grade index is comparable to Delgold with a slightly higher yield. Per cent "O" grades is less and per cent "L" grades is more than Delgold and Delfield. Typically, topping is about 1 day later than Delfield. CT 166 is slightly taller than Delfield with similar leaf counts. Tip leaf dimensions and tip leaf area are similar to Delgold and Delfield. Tolerance to black root rot is intermediate. Ground sucker pressure is greater than with Delgold and Delfield.

CT 572

Registered in 2001. It is a cross between Canadian breeding line TB5-2 and American variety K149. Yield and grade index are higher than Delgold and Delfield. Days to topping is about 3 longer, and it has one leaf more than Delgold. CT 572 produces more "M" grades but slightly less "O" grades than Delfield. Brown spots in the bottom leaves were observed on wet years but had no noticeable effect on yield and quality. Tolerance to black root rot is similar to Delgold. Company evaluations and grade index are higher than Delfield and Delgold.

CT 681

Registered in 1999. Developed from repeated selections for high tolerance to black root rot from the variety AC White. Similar to AC Gayed, CT 681 should perform well where black root rot is a problem. CT 681 has some of the same characteristics as AC White. Typically it is above average in yield with a good "O&M" grade mix. The days to topping are a couple of days longer than Delgold and Delfield. Plant height and leaf numbers are similar to Delgold and Delfield, but the length and width of leaves at the 8th leaf position and tip position are larger. Some growers commented that the leaves can grow too large if this variety is overfed with nitrogen. Others said CT 681 appears more susceptible to Blue Mold than some other varieties.

Delfield

Registered in 1990. Derived from crosses involving a somatic hybrid (*Nicotiana rustica* x *Nicotiana tabacum*), Delgold and Newdel. This cultivar might contribute to undesirable leaf chemistry under certain conditions. If you choose this cultivar, be aware of your leaf chemistry results. This variety has intermediate tolerance to black root rot. Plant height and leaf number are similar to Delgold. The top stretches quickly and usually is topped earlier than Delgold. Grade index is slightly higher than Delgold, but yield is similar. In optimum production conditions, Delfield will tend to produce more of the mature (i.e., "O &M") styles of tobacco than Delgold.

Delgold

Registered in 1980. Derived from crosses involving *Nicotiana rustica*, Hicks Broadleaf, and Virginia 115. The plant is light green and fast growing in the greenhouse and field. Ground sucker growth is quite low. The variety is high yielding and has intermediate tolerance to black root rot. In the cured leaf, shades of light orange predominate throughout the mid-stalk leaves while the upper leaves range from light orange to orange.

Delliot

Registered in 1986. Derived from crosses involving *Nicotiana rustica*, Delhi 34, and Virginia 115. Delliot has exhibited good vigour and rapid growth in the greenhouse and field. It is a tall variety with well-spaced leaves and very little ground sucker growth. Leaves become crinkly as they approach maturity. Delliot has an intermediate tolerance to black root rot and appears slightly more susceptible to weather fleck than Delgold. Occasionally premature leaf breakdown is observed with Delliot, but in most situations this has not resulted in significant economic loss. Although Delliot typically produces fewer leaves than Delgold, overall yield is often similar.

RG 17

Restricted registration under the *Canada Seeds Act* until January 11, 2004. RG 17 was first registered in the United States. Derived from a cross between K 326 and K 399. The 3-year average from trials conducted in 1998–2000 indicates that RG 17 has a comparable grade index to Delgold and Delfield but a slightly lower yield. Days to topping is 2 longer than Delfield and Delgold. Plant height is shorter than Delfield, but leaf number is the same. RG 17 has less ground suckers than any of the varieties and an average black root rot tolerance. Total "O&M" grades are higher and "F", "G" and "CR" grades lower than Delgold and Delfield. The company evaluations are similar to Delfield but higher than Delgold.

RG 81

Restricted registration under the *Canada Seeds Act* until January 11, 2004. RG 81 is a conventional variety first registered in the U. S. Derived from crosses between K 326 and K 399. The 3-year average from trials conducted in 1998–2000 indicates that RG 81 provides a higher grade index than Delgold and Delfield. In other comparisons to Delgold and Delfield, RG 81 is similar in yield and black root rot tolerance, about 2 days later topping and slightly shorter in plant height. The leaves tend to be smaller than Delgold and Delfield. Total "O&M" grades are higher and "F", "G" and "CR" grades lower than Delgold and Delfield. The company evaluations are similar to Delfield but higher than Delgold.

Table 3-1. Tobacco variety performance (3–year average, 2000–2002)

Variety	Yield (kg/ha)	Grade index (¢/kg)[1]	Days to topping	No. of leaves	Topping height (cm)	Leaf spacing (cm)	Area 3 tip leaves (cm^2)	Ground suckers (kg/ha)[2]	Black root rot index[3]	% O&M grades	Company evaluation[4]
Delfield	3,210	476	61	18	95	5.5	1,132	19.1	3.8	53.8	71
Delgold	3,202	466	62	18	95	5.4	1,116	11.3	3.9	42.4	67
Delliot	3,172	460	63	16	101	6.4	1,218	10.7	4.6	24.6	67
AC Cheng	3,178	473	63	17	96	5.7	1,230	8.8	4.0	36.5	64
AC Gayed	3,092	451	61	17	92	5.6	1,155	13.4	7.6	27.0	65
AC White	3,305	463	65	18	97	5.4	1,114	13.2	4.2	36.4	70
CT 157	2,971	491	65	18	98	5.4	1,083	13.3	3.7	65.4	82
CT 166	3,296	468	63	18	98	5.4	1,116	22.4	3.5	29.0	62
CT 681	3,437	456	65	18	97	5.5	1,186	12.7	7.2	33.9	68

1 Prices are based on 1998 grade price.
2 Ground suckers (kg/ha) data was collected during mid-July, shortly after hilling.
3 Rating is based on a scale of 1 (susceptible) to 10 (immune).
4 Rating is based only on visual attributes of the cured leaf. Higher number = better rating.

Table 3-2. Tobacco variety performance (2–year average, 2001–2002)

Variety	Yield (kg/ha)	Grade index (¢/kg)[1]	Days to topping	No. of leaves	Topping height (cm)	Leaf spacing (cm)	Area 3 tip leaves (cm^2)	Ground suckers (kg/ha)[2]	Black root rot index[3]	% O&M grades	Company evaluation[4]
Delfield	3,726	474	62	19	98	5.2	1,275	26.5	3.8	58.0	68
Delgold	3,660	465	63	19	97	5.2	1,277	15.2	3.8	51.4	63
Delliot	3,653	449	64	17	106	6.3	1,365	15.0	4.0	20.6	62
AC Cheng	3,610	471	63	18	100	5.5	1,408	12.7	3.9	45.8	62
AC Gayed	3,574	454	60	18	94	5.3	1,323	19.0	7.2	30.8	64
AC White	3,874	465	65	20	101	5.2	1,262	19.2	3.7	45.5	68
CT 144	3,853	482	66	20	102	5.1	1,192	15.3	4.3	51.2	67
CT 157	3,465	486	65	20	104	5.3	1,219	20.0	3.9	70.0	80
CT 166	3,791	465	63	20	101	5.1	1,245	31.9	3.6	34.6	58
CT 572	3,833	490	66	20	99	5.2	1,196	21.4	4.1	79.6	77
CT 681	4,082	456	65	20	101	5.2	1,338	17.8	7.0	39.3	67

1 Prices are based on 1998 grade price.
2 Ground suckers (kg/ha) data was collected during mid-July, shortly after hilling.
3 Rating is based on a scale of 1 (susceptible) to 10 (immune).
4 Rating is based only on visual attributes of the cured leaf. Higher number = better rating.

Table 3-3. Tobacco variety performance (1–year data, 2002)

Variety	Yield (kg/ha)	Grade index (¢/kg)[1]	Days to topping	No. of leaves	Topping height (cm)	Leaf spacing (cm)	Area 3 tip leaves (cm^2)	Ground suckers (kg/ha)[2]	Black root rot index[3]	% O&M grades	Company evaluation[4]
Delfield	3,696	466	60	19	98	5.1	1,380	24.0	3.8	56.4	69
Delgold	3,520	462	60	19	94	5.0	1,432	9.0	4.4	50.8	59
Delliot	3,648	445	60	17	100	6.0	1,591	27.0	4.0	27.2	62
AC Cheng	3,557	463	60	18	97	5.4	1,563	17.8	4.0	43.6	61
AC Gayed	3,627	450	59	18	94	5.1	1,395	12.0	6.4	37.0	62
AC White	3,790	455	62	20	99	5.0	1,441	28.2	4.2	37.6	66
CT 144	3,831	473	63	21	101	4.8	1,359	12.0	4.0	49.3	65
CT 157	3,321	477	62	20	100	5.1	1,365	10.5	4.2	69.1	80
CT 166	3,741	473	61	20	99	4.9	1,366	25.5	3.8	35.9	57
CT 572	3,681	485	64	20	100	5.1	1,345	27.0	3.9	76.2	74
CT 681	4,116	444	62	20	102	5.1	1,468	19.0	5.3	28.5	62
RG 17[5]	3,761	422	62	21	102	5.0	1,261	53.3	3.3	11.7	53
RG 81[5]	3,762	483	63	21	101	4.9	1,286	44.9	3.9	75.6	68

1 Prices are based on 1998 grade price.
2 Ground suckers (kg/ha) data was collected during mid-July, shortly after hilling.
3 Rating is based on a scale of 1 (susceptible) to 10 (immune).
4 Rating is based only on visual attributes of the cured leaf. Higher number = better rating.
5 Varieties with a restricted registration under the *Canada Seeds Act*, expiring January 11, 2004.

4. Seedling Production

Cultural practices

Growth medium

Muck beds

A uniform muck layer, at least 7.5 cm (3 in.) thick, is required to provide good conditions for seedling growth. Rather than removing the old muck each year, most growers add a small quantity of new muck.

A 2.5 cm depth on 100 m^2 requires 2.5 m^3 of new muck, while 1 in. on 1,000 sq ft requires 3.1 cu yd.

An alternative to new muck is artificial media such as peat or peat-based mixtures. No doubt these materials improve the performance of old muck, but there are no clear indications they work better than new muck.

Plug trays

Use a commercial soilless media recommended by the manufacturer for seedling production in plug trays. Media texture and moisture content must be adequate for the tray filling equipment to be used. Media that is too fine or dry falls through the tray bottoms during stacking and moving. Pack the trays just enough to ensure that the cells are filled to the bottom. Incomplete filling of the cells or media falling out the bottom when the trays are stacked results in dry cells when the trays are placed in float tanks. About 4.7–5.3 L of media is required per tray.

Seeding rates

The amount of seed needed for a good stand of plants (110–120 per 930 cm^2 or sq ft) varies with management, type of greenhouse, and whether vermiculite is used as a covering after seeding. Table 4-1 on page 37 lists final plant populations based on seeding rate and seedling survival.

The seeding rate without vermiculite should be about 28 g on 165–220 m^2 (1 oz on 1,800–2,400 sq ft).

Consider your experience with the specific greenhouse and your past management practices when deciding the seeding rate.

Reduce the seeding rate by 15%–20% if you plan to use vermiculite as a covering after seeding, i.e., 28 g on 194–260 m^2 (2,100–2,800 sq ft).

CAUTION

Some pumps and pumping systems used in seeding can damage seeds and significantly reduce plant stands. Don't use gear, roller or high-volume piston or centrifugal pumps or systems that recirculate the seed-water mixture. Low volume (<30 L/min) piston or centrifugal pumps are safe if the seed-water mixture is hand-agitated rather than recirculated and the seed is not germinated beyond the stage when white radicles become visible.

For more information on seedling production refer to OMAF Factsheets, *Producing Tobacco Transplants in Ontario*, Order No. 86–062 and *Culture of Tobacco Seedlings in Todd Cells*, Order No. 82–038.

Time of seeding

Seed early enough to have plants near transplanting size before mid-May. This allows time for hardening-off before planting begins. The proper seeding time varies, depending mainly on the type of greenhouse and whether the seed is pre-germinated.

About 7 weeks are needed to raise seedlings in float trays.

If you use pre-germinated seed, you may have to seed "slow" greenhouses during the last 4 or 5 days in March. The first 4 or 5 days in April may be appropriate for warmer greenhouses. Where seed is not pre-germinated, earlier seeding is advised.

Table 4-1. Final plant populations per 930 cm² (1 sq ft)

Seeding rate			Seedling survival					
Area seeded using 28 g		seeds per 930 cm² (sq ft)*						
m²	sq ft		85%	80%	75%	70%	65%	60%
167	1,800	194	165	156	146	136	126	117
186	2,000	175	149	140	131	123	114	105
204	2,200	159	135	127	119	111	103	95
223	2,400	146	124	117	109	102	95	88
242	2,600	135	114	108	101	94	88	81
260	2,800	125	106	100	94	88	81	75
279	3,000	117	99	93	88	82	76	70
297	3,200	109	93	88	82	77	71	66
316	3,400	103	88	82	77	72	67	62
334	3,600	97	83	78	73	68	63	58
353	3,800	92	78	74	69	64	60	55

* Based on 350,000 seeds per 28g (1 oz.). Shaded values show rates within the optimum range for precision seeding

Examples:

1. A seeding rate of 117 seeds per 930 cm² (1 sq ft) with precision seeding provides 99 plants per 930 cm² if the survival rate is 85%. The area covered by 28 g of seed sown at 117 seeds per 930 cm² is 279 m² or 3,000 sq ft
2. A seeding rate of 28 g on 223 m² (2,400 sq ft) of seedbed with water seeding is equivalent to 146 seeds per 930 cm². If the final plant stand is 109 plants per 930 cm², the seedling survival is 75%.

Heating

Supplemental heating of greenhouse air greatly improves the speed and uniformity of tobacco seed germination and is a necessity for tobacco transplants grown in plug trays. Seedling uniformity is particularly important in any plug-plant system where plants are pulled from the trays only once. With good greenhouse management, about 85% useable plants can typically be obtained from plug trays.

The optimum temperature for germination is about 24°C (75°F). However, very good germination results can be obtained at a temperature of about 15°C (59°F) with substantially reduced energy costs. Supplemental heat to at least 15°C should be maintained for the first 14 days after seeding. After the seedlings emerge, a minimum night temperature of about 10°C (50°F) is enough for good rates of growth. Temperatures can drop to as low as 3°C (38°F) without causing excessive damage.

In the float tray system, heating float tank water does not significantly increase the surface temperature of the growth media and is not nearly as effective as maintaining the greenhouse air temperature at a minimum of 15°C during germination. Float water temperatures are typically at, or even somewhat above, the optimum range for root growth without any additional heating of the water. Insulation between the soil and plastic float bed liner does not significantly improve seedling growth. The soil under the plastic liner is initially a heat sink that cools the water but later in the season acts as a heat source on cold nights.

Greenhouse heaters are typically fired with wood, oil, natural gas or propane. The products of combustion from greenhouse heaters should be vented to the outside. Even a relatively clean burning fuel such as propane needs 15 m³ of air to burn a litre of fuel and may deplete the oxygen levels in the greenhouse during severe cold. Fuel combustion under low oxygen conditions may produce pollutants that can damage small plants and may also be dangerous to greenhouse workers.

Precision seeding

Optimum seeding rates for precision seeding range from 90–120 seeds per 930 cm² (1 sq ft). Special equipment using pelleted seed is required. One 28 g package of tobacco seed produces about 350,000 seed pellets. At a rate of 100 seeds per 930 cm² (1 sq ft), 28 g of seed covers 325 m² (3,500 sq ft). With an expected 85% survival, this seeding rate produces 85 plants per 930 cm². *Table 4-1. Final plant populations per 930 cm² (1 sq ft)* indicates final plant populations based on seeding rate and seedling survival.

If your seed is pelleted in the United States, order in December to ensure the seed is available when you need it. Seeding should be at least one week earlier than normal seeding with pre-germinated seed.

Plug tray seeding

Special seeding equipment and pelleted seed is required for plug trays. Missed cells or double seeded cells should be kept to a minimum, under 3% if possible. Seed placement is more critical with plug tray systems. Seeds should be placed near the centre of the cells for best growth and very lightly covered with media or horticultural grade vermiculite so that just the very tops of the pellets are showing.

Trays can be seeded, stacked on pallets and stored in a cool room protected from direct sunlight and excessively dry or humid conditions for a few weeks before starting. Seedling growth can be initiated by moving the trays to the greenhouse or by moistening the cell media and holding the stacked trays in a controlled environment room for about 5 days at about 25°C (77°F) and 90% relative humidity, then moving the trays to the greenhouse.

Using vermiculite

Vermiculite applied as a covering after seeding helps reduce plant loss from excess heat, dryness or tipping-over.

Several grades of vermiculite are available, but use only the grade specified for tobacco seedbeds. Using other grades that are finer or applying too much tobacco grade is likely to reduce seedling emergence.

Cover the seedbed surface almost, but not completely, with vermiculite. For example, one 7 kg bag likely provides enough coverage on 35–40 m^2 of seedbed (400–450 sq ft). Use a lower rate of vermiculite where the seedbed surface is grooved as a result of precision seeding. This prevents too thick an accumulation of vermiculite in the grooves once the seedbed is watered.

Uniform application is essential since plants may not emerge where there is a complete or thick covering of vermiculite.

As suggested under "Seeding rates" on page 36, apply 15%–20% less seed when you plan to use vermiculite immediately after seeding.

Muck bed cover

Observations suggest that a lightweight woven cloth (similar to a floating row cover) may be used to cover muck seedbeds in unheated greenhouses. The cloth provides a small amount of insulation that can increase minimum overnight temperatures by about 2°C (3.6°F). This small temperature increase improves seedling growth, especially in greenhouse areas prone to cold injury and slower than normal growth. The cloth has been used with good results in certain areas of greenhouses to promote better uniformity across the seedbeds. In unheated muck bed greenhouses, the areas typically covered are the outside 1 m (3 ft) of seedbed next to the side walls and the final 10 m (33 ft) of seedbed opposite the air exhaust fans.

Hardening-off

Muck beds

Plants must be hardened off to withstand drying conditions in the field and to permit rapid recovery from transplant shock. Hardening-off is used to reduce the rate of growth and exposes plants as much as possible to field conditions.

Plants should be near transplanting size before mid-May to allow time for hardening without delaying the start of planting.

Loosening the seedbed with a fork is one of the best methods of reducing the rate of top growth and also stimulating the growth of new roots. Loosening is usually done 7–14 days before planting when the plants have 3–7 cm (1.2–2.8 in.) of stem. Prior to forking, let the seedbed dry until the plants wilt slightly, but not severely, during the day and recover overnight. Insert the fork at 20 cm (8 in.) intervals to a depth of 15–20 cm (6–8 in.) , and pull the handle back enough to move, but not lift, the seedlings. After forking, you can restrict or withhold water for 2–3 days, and provide full ventilation day and night to induce fairly severe wilting, unless there is a threat of frost. Do not allow the leaves to wilt to the point of permanent damage or burn.

Another method of hardening involves withholding water until plants wilt severely during the day and recover at night. Full ventilation, both day and night, is usually provided unless there is danger of frost. This method does not work well unless sunny weather prevails during the 5–7 days required for toughening. If the weather is cool and cloudy, a bet-

ter method may be to close the greenhouse during the day and try to cause the plants to wilt with heat. Be careful, especially in tight greenhouses, to avoid extremely high temperatures that may permanently damage the plants.

Clipping to remove the upper canopy of leaves to just above the heart is another method of toughening plants and reducing the rate of growth. Clipping opens up the canopy, permitting sunlight to penetrate the seedbed. This tends to enhance the growth of the smaller, unclipped seedlings and improve overall uniformity in the size of the plants. The additional light is also thought to toughen the seedling stems. Clipping normally starts about 2 weeks before the first pulling of seedlings and may be repeated several times depending on rate of growth. After clipping, you can restrict or withhold water for 1 or 2 days as an additional hardening treatment if needed. Another effective way to produce desirable seedlings is to fork 2 weeks before the first pulling, followed by clipping a few days before and perhaps during transplanting.

Carry out good sanitation practices in the greenhouse. Diseases such as tobacco mosaic virus and bacteria can be spread when clipping tobacco seedlings. Between clipping in each greenhouse wash the blades and underside of the clipper thoroughly with soapy water, then sanitize with 2.6% solution of sodium hypochlorite (mix 1 part common household bleach with 1 part water). Rinse with water. It is also important to prevent the clipping debris from falling into the trays or seedbed since this could start disease.

Float trays

Clipping is the best method available to float system transplant growers for controlling plant growth and promoting uniformity. The clipping system should be easy to use and not drop a lot of plant material onto the trays. Dropped leaf clippings can lead to disease problems.

Clip plants as early as possible for maximum control of growth rate and promotion of uniformity. Typically the first clipping is about 4–5 weeks after germination. Clip plants 4–6 cm (1.6–2.4 in.) above the growing point, or heart, about every 3 days, depending on rate of plant growth. Avoid removing more than 2 cm (0.8 in.) of top plant growth during the week just prior to transplanting.

To control plant growth rate, allow the greenhouse to cool down and vent excessive humidity by running the exhaust fans periodically, even on cool days. Temperatures can drop to as low as 3°C (37°F) without any serious plant injury.

High electrical conductivity (EC) levels in the float water created by the addition of large amounts of fertilizer slow plant growth somewhat. This technique is not a replacement for clipping or proper management of greenhouse temperature and humidity. An EC level of 5–6 mS/cm produces a slower growth rate and some moderate afternoon wilting of the plants on hot days. Proper disposal of high EC float water, especially if high in nitrates, is a concern. It is important that nitrates not be allowed to contaminate ground or surface waters. We cannot recommend mixing fertilized float water with any pesticide for use as transplant water.

Fertilization

More information on fertilizing seedlings produced by other methods may be obtained from the Southern Crop Protection and Food Research Centre, Delhi, and in the OMAF Factsheet, *Culture of Tobacco Seedlings in Todd Cells*, Order No. 82–038.

Do not use growth media that contains composted sewage sludge.

Testing greenhouse media

Nutrient levels, pH, and total salts can be determined by submitting samples of seedbed soil to an OMAF-accredited lab. Samples should be taken from the top 5–7 cm (2–2.8 in.) of seedbed. To find out if any variation from the general fertilizer recommendations is required before seeding, take samples in the fall after any new muck has been incorporated. Samples may also be taken in April for guidance on fertilization requirements in May.

Testing float water

While water quality has not been found to be a major problem in Ontario, growers should have a complete water analysis done by an OMAF-accredited lab for each water source before growing their

first float system seedlings. Information on the interpretation of analysis results and adjustments to water chemical characteristics are available from the OMAF tobacco specialist.

Fertilization before seeding

Muck beds

Apply 25 kg of 4–30–8 special tobacco seedbed fertilizer per 100 m^2 of seedbed area.

Fertilizer may be applied before or after steaming. Spread the fertilizer uniformly and thoroughly mix with the top 4 cm of seedbed.

CAUTION

High rates, shallow incorporation and uneven distribution of fertilizer may cause a problem with soluble salts, resulting in thin stands and patchy growth.

Float trays

Fertilizing float water is not necessary before seeds have germinated and plants have developed to the early 2-leaf stage. The growth media contains enough nutrients to meet seedling requirements at this early stage of development.

Using good quality horticultural-grade water-soluble fertilizer is highly recommended. Fertilizer calibration trials and grower experience suggest that float system fertilizer should be relatively low in phosphorus (about 40% of N level) and high in nitrate vs. ammonia source nitrogen (>60% nitrate source N). Also, this type of fertilizer should not contain urea source nitrogen and should contain micronutrients. Excellent results have been obtained with a 20–8–20 analysis fertilizer plus micronutrients.

As soon as seedlings germinate, add fertilizer at a rate of 100–200 ppm nitrogen to the float water and mix it thoroughly. It is very important that the seedlings do not become nutrient deficient. Use a conductivity meter (EC or salt meter) to monitor fertility levels during seedling growth and add more fertilizer as needed to maintain at least 100 ppm nitrogen. Each fertilizer formulation has its own unique relationship between the EC level it produces when mixed with water and the nitrogen concentration. You can use this relationship to monitor and adjust the fertility level of the float water over the course of the seedling growth.

Fertilization during May

Muck beds

If tests or observations show the need, apply liquid, soluble powder or granular fertilizer at least 2 weeks before planting at a rate that will supply 0.25 kg of nitrogen (N) per 100 m^2 of seedbed area (0.5 lb per 1,000 sq ft). For example, a soluble complete fertilizer containing 15% nitrogen would be applied at the rate of 1.7 kg dissolved in at least 200 L of water per 100 m^2. Wash the solution off the plants immediately after application to prevent burning.

If plant growth is slow and leaves are pale green, this treatment may be repeated.

Nitrogen deficiency often occurs during early May, especially in over-watered seedbeds. Chemically sterilized seedbeds may be more prone to this problem than those that are steam sterilized. The feeding program recommended above should begin in the first week of May in these seedbeds.

Potash deficiency occasionally develops in seedbeds with a high proportion of new muck and fertilized with the normal rate of 4–30–8. A whitish-yellow mottling of the interveinal tissue of the older leaves is a sign of potash deficiency. Although the lack of potash is seldom severe enough to affect growth, fertilizing during May with a complete fertilizer is better than using one that supplies only nitrogen.

Soluble salts

Muck beds

High levels of soluble salts often accumulate in the seedbed. This can cause reduced or delayed germination, tipping-over, stunting and root damage. Fertilizer is generally the main source of salts, although the water from some wells may be high in salts.

Preventing salt problems

In greenhouses with poor drainage or previous salt problems, remove old muck completely and replace it with new muck each year.

To avoid salt problems, leach the seedbed in the fall before spreading new muck. For effective and uni-

form leaching, moisten the seedbed thoroughly with a sprinkler to the depth of the existing soil moisture or to at least 30 cm. Do this late in the summer or during the fall. It may take several days until the seedbed is uniformly moist. Then apply at least 10,000 L of water per 100 m^2 of seedbed area. This may be done by flooding or with a sprinkler. Repeat after 3 or 4 days.

Do not apply more than the recommended amount of fertilizer before seeding.

CAUTION

Thorough moistening before flooding is essential. Flooding a dry seedbed results in uneven water penetration that removes salt in some areas but not others.

Correcting salt problems

During the greenhouse season, salt problems usually occur in the areas of the seedbed that dry most rapidly (loose areas or areas receiving less water).

Leaching can correct this problem. In fact, if the problem is detected early enough, corrective measures can produce a normal stand of plants. Samples of muck from the seedbed can be tested for soluble salts at the OMAF-accredited laboratories listed on page 19.

Water by hand to leach high-salt areas so that the large quantity of water required is applied only to the problem areas. The best procedure is to water the areas of high salts until surface puddling begins. Allow time for the water to penetrate, then repeat the procedure. Do this several times. Continued spot-watering will likely be required to obtain a uniform seedbed.

Float trays

Salt or EC levels in float water are predominantly a measure of the type and amount of fertilizer in the water and are not typically the source of seedling growth problems unless the levels are extreme (<1 or >5 mS/cm).

Disease control

Muck bed sterilization

Sterilization of the entire seedbed is needed to get rid of weeds, soil-borne diseases and nematodes.

Steaming

Steaming is the most consistent and reliable sterilization method, provided the soil is in proper condition and enough time is taken to obtain the required temperature.

Steaming may be done in the fall or spring. Conditions in the fall are likely to be more favourable than in the spring when frozen soil is often a problem. Fall steaming also allows time for the recovery of soil microorganisms. Some of these microorganisms may compete with damping-off fungi, reducing their spread and development. One disadvantage of fall steaming is the possible re-infestation of the seedbed with weed seeds and diseases caused by glass breakage during the winter.

The usual method is to inject steam under a metal pan, although large plastic sheets are sometimes used.

To provide optimum conditions for steam penetration the seedbed should be uniformly loose with just enough moisture for the germination of seeds.

For thorough sterilization, you need a temperature of 82°C (180°F), held for 30 minutes at a 15 cm (6 in.) depth. This usually means steaming under pans for half an hour. Three to 5 hours may be required when a plastic sheet is used, depending on soil condition, type of steamer and size of the sheet. Use a soil thermometer to determine the necessary steaming time.

STOP!

Before you use any pesticide read Chapter 1 of this guide and follow all precautions.

Fumigating

Basamid, Vorlex Plus and Vapam may be used as alternatives to steaming. Apply them in the fall, preferably before the end of October. Late fall or spring application is likely to damage germinating tobacco seed and young seedlings.

Acceptable control of weeds, most fungi and nematodes is usually obtained with these chemicals. However, there has been some variation in effectiveness in controlling black root rot, which can be a serious problem in the seedbed. Thorough steaming is the most reliable means of controlling black root rot.

Having the seedbed prepared and thoroughly moistened at least a week before treatment is essential. Enough moisture for seed germination must be maintained during the 7 or more days before treatment. Avoid excess moisture.

The following amounts of material are for 100 m^2 of seedbed area:

Basamid	3.25–5 kg
Vorlex Plus	6 L
Vapam	10 L in 800 L water

Consult product labels for more information on their proper use.

Treating walls, walks and boards

Disease organisms harboured on walls, walks and boards may contaminate the sterilized seedbed. A formaldehyde solution (1 L of Formalin to 25 L of water) applied to these areas after steaming and 4–5 days before seeding is effective in reducing seedling diseases, particularly those causing damping-off. Try to apply the solution on a warm day. After applying, close the greenhouse for 2 days. Then open it for at least 2 days before seeding to allow harmful vapours to escape.

Be careful to avoid drenching areas of the seedbed with the formaldehyde solution. Damage to germination and seedling growth may occur where the seedbed is drenched with formaldehyde 4–5 days before seeding.

Plug tray sterilization

Algae growth on the media surface and on the upper sides of the cells does not appear to seriously affect seedling growth in the float system.

This is not the case for overhead watered plug trays, where algae growth can prevent the downward movement of water and fertilizer into the media and the plant roots. However, for both systems, wash trays with dried algae deposits from the last growing season with water and a mild soap, possibly with a moderate pressure power washer, and rinse with clean water as soon as possible after the trays are emptied. Styrofoam trays are much more difficult to clean after the algae has dried. Although washing does not sterilize the trays, it does delay the development of new algae when the trays are used again.

Trays can be sterilized by steaming. If the trays are stacked on pallets, take care that the steam reaches all the tray surfaces in the stack and that a minimum temperature of 71°C (160°F) is maintained for 30 minutes. Trays exposed to temperatures greater than 79°C (174°F) may shrink, warp or distort.

Damping-off (bed rot)

Muck beds

Damping-off is caused by organisms (mainly *Rhizoctonia* and partly *Pythium*) present in most soils. It may affect seedlings just as they are emerging, causing the plants to shrivel and die. Later the disease may be indicated by a wet rot that develops where plant stems and leaves decay at the ground surface. The disease is often found in patches throughout the seedbed and is usually most serious where there is a thick stand of plants. In most cases, recontamination of the sterilized seedbed is the main cause. Conditions such as humid air, wet seedbed soil and thick stands of seedlings favour development of damping-off.

Control

Preventing or controlling damping-off depends on good greenhouse management and the proper use of fungicides. When damping-off first appears, apply Benlate 50% WP at 125 g in 230–320 L of water per 100 m^2. Repeat if necessary.

Benlate provides good control of the more common *Rhizoctonia* type of damping-off.

Apply Ridomil Gold 480 EC to control *Pythium*. Mix 12 mL of Ridomil Gold 480 EC in 100 L of water and apply to 100 m^2 of plant bed. Apply within the 3 days before seeding. Do not apply Ridomil Gold 480 EC with equipment that has been used for herbicide application.

The following steps help prevent and control damping-off:

- Loosen the seedbed to promote good drainage.
- Sterilize the soil thoroughly.
- Sterilize shoes and tools before walking and working in a sterilized seedbed. Use a formal-

dehyde solution mixed 1:25, Formalin to water.
- Treat walls and walkways with a formaldehyde solution.
- Use the recommended seeding rates.
- After the plants cover the seedbed do not water in the afternoon.
- Ventilate as much as possible.
- Aim to have the seedbed surface as dry as possible by evening.

Plug trays

Temperature control may help prevent the rapid spread of disease in the greenhouse. Research data indicates that at 15°C (59°F) the growth and development of the common tobacco greenhouse diseases are minimized.

By not seeding too early, the time that plants are in the greenhouse can be limited to about 7 weeks. Holding plants late in the season can increase the risk of developing disease.

Black root rot

The disease is found where the soil has not been properly sterilized. Usually small areas of the seedbed are affected. Transplanted diseased plants are very slow to start growing.

Control

Thorough steaming is the most reliable means of controlling this disease. Avoid deep working of the seedbed after sterilizing.

Blue Mold

On small seedlings, the first leaves lose their normal green colour and a grey-to-bluish mould develops. Larger seedlings show a more pronounced yellowing and often wilt slightly. Affected seedlings are unsuitable for transplanting as they remain stunted and the brittle stems are easily broken by the wind.

Control

Steam sterilization of the seedbed and treatment of the walls and walkways with a formaldehyde solution (as described under "Muck bed sterilization" on page 41) are recommended to destroy any Blue Mold contamination in the greenhouse.

Apply Dithane M-45 or Dithane DG. Dithane is a preventive fungicide program for Blue Mold in flue-cured tobacco greenhouses. Begin treatments when the seedlings cover the seedbed or trays and then twice a week until transplanting. Do not treat earlier, as injury to the seedlings could occur. Do not apply Dithane under hot conditions.

Use 50–100 g of Dithane fungicide in 25–50 L of water and apply to 100 m^2 of seedbed (1.6–3.3 oz in 5–10 gal of water over 1000 ft^2 of seedbed).

Use the lower rate and lower water volume when the seedlings have just covered the surface of the seedbeds or trays. Increase the product rate and water volume as the seedlings become larger. Apply the spray when the seedling foliage is dry. Use proper spray equipment so that the spray wets the seedlings without run-off. Do not use the greenhouse watering system because it applies too much water. Allow the spray to dry on the seedlings before resuming normal watering.

In float greenhouses do not allow Dithane to contact the float water.

Aim to have the foliage dry by evening by not applying water in the afternoon and ventilating as much as possible.

When cleaning out greenhouses, tobacco seedlings should be raked up and allowed to dry up completely inside the greenhouse before disposal. Do not dispose of living plant material outside the greenhouse since this could be a source of disease or a host for insects.

Yellow patch

The symptoms of yellow patch are irregular patches of yellow, stunted plants in the seedbed. Affected roots show various degrees of discolouration and rotting. In severe cases the seedlings die. In milder cases new rootlets develop above the rotted ones and the plants may recover.

Control

This problem is caused mainly by excessive fertilizing before sowing and can usually be prevented by following the fertilizer recommendations. If yellow patch develops, some relief can be obtained by allowing the soil to dry out thoroughly for about 2 days and then watering heavily to leach out some of the excess fertilizer. See "Correcting salt problems" on page 41. Excessive compaction of the seedbed soil tends to aggravate this condition.

2,4-D injury

Symptoms vary depending on the amount of 2,4-D to which the plants are exposed. The most obvious symptom is extreme leaf distortion. Affected leaves droop and are narrow and often strap-shaped with very prominent veins and wavy or deeply-toothed margins. In many cases the surface is blistered. In mild cases the plants may recover. In severe instances there is no recovery.

Control

Tobacco plants are sensitive even to small amounts of 2,4-D. Any sprayer or other equipment that has been used for 2,4-D should never be used on tobacco. Do not spray with 2,4-D near tobacco seedbeds or fields because there is always the danger of spray or vapour drift.

Atrazine damage

When this material is present in the seedbed at or soon after seeding, plants emerge but soon dry up and disappear. When applied to larger plants in the seedbed, atrazine causes a yellowing of the leaves, especially the tips and margins. Depending on the amount, leaves or entire plants may die.

Symptoms of damage from Bladex and other triazine herbicides are similar to those caused by atrazine.

Control

When you spray tobacco, never use sprayers or parts of spray equipment that have been used to apply atrazine or other triazine herbicides. Be careful not to contaminate water supplies. Never fill the herbicide sprayer near the greenhouse.

For more information on diseases affecting tobacco, refer to Agriculture & Agri-Food Canada Publication 1641, *Tobacco Diseases* and OMAF Factsheet, *Blue Mold of Tobacco*, Order No. 83–068.

Insect control

Cutworms

When damage appears spray the plants in the evening with one of the following per 100 m^2 of seedbed area in 15 L of water:

Ripcord 400EC	3 mL
Dylox 420 EC	90 mL
Decis 5 EC	4 mL
Cymbush 250 EC	4.8 mL

Harvester ants

The pavement ant is the most common species of harvester ant being detected in an increasing number of tobacco seedbeds. These ants remove tobacco seed and very young seedlings, often causing severe reductions in the supply of transplants. By nesting only along walkways and walls they are less easy to detect than mound-building ants that form hills on the seedbed surface.

Use Diazinon 50W to control pavement ants on flue-cured tobacco seed and seedlings in greenhouses. Treatment can be before or after seeding. Apply 12.5 g in 10–15 L of water per 100 m^2 of seedbed. Apply only to areas where ants are actively foraging. If ants reappear in 2 weeks, treat again.

5. Weed Management

With a few exceptions, the chemicals are listed under their common (generic) rather than their trade or product name. See *Table 1-5. Pesticides used in producing flue-cured tobacco* on page 14 to determine the corresponding common name for a particular trade name. For example, the trade name Devrinol has a common name of napropamide. Notes on Devrinol are listed under napropamide.

Adjuvants

See Agral 90, AG-Surf, Companion, Enhance, Frigate.

Agral 90

Type of adjuvant: Non-ionic surfactant.
Chemical composition: Nonylphenoxy polyethyoxyethanol 90%.
Registered uses: For use with diquat, paraquat, glyphosate, imazethapyr, rimsulfuron, nicosulfuron/rimsulfuron and for washing sprayer tanks and equipment.
Benefit: Improves chemical effectiveness.
Mode of action: A wetting and spreading agent that improves coverage of spray mixes.
Mixing: Use 250-1000 mL/1000 L of spray as specified on label. Mixes with all types of water. Add Agral 90 to the spray mixture and agitate thoroughly.
Characteristics: Do not exceed recommended rates of Agral 90 as too much wetting agent can cause excessive run-off, leading to loss of spray.

AG-Surf

Type of adjuvant: Non-ionic surfactant.
Chemical composition: Nonylphenoxy polyethyoxyethanol 92%.
Registered uses: For use with glyphosate, imazethapyr and fluazifop-p-butyl.
Benefit: Improves chemical effectiveness.
Mode of action: A wetting and spreading agent that improves coverage of spray mixtures.
Mixing: For use with Roundup: when applying the 2.5 L/ha of water, add AG-Surf at 0.5% (0.50 L/100 L water) to maintain adequate surfactant concentration.
For use with Roundup to control annual grasses and broadleaf weeds for minimum or zero-till: use 350 mL/ha plus Roundup at 1.1 L/ha in 50-100 L/ha of clean water.
For use with Fusilade 250EC: add 100 mL of AG-Surf for each 100 L of spray solution (0.1%). An anti-foaming agent may be required to reduce foaming.
Characteristics: Do not exceed recommended rates of AG-Surf, as too much may cause excessive run-off, reducing effectiveness of the herbicide. Consult product label for full directions.

Companion

Type of adjuvant: Non-ionic surfactant.
Chemical composition: Octylphenoxy-polyethoxy-(9)-ethanol 70%.
Registered uses: For use with chlorsulfuron.
Benefit: Improves chemical effectiveness.
Mode of action: A wetting and spreading agent that improves coverage of spray mixes.
Mixing: For use with glyphosate for the control of annual grasses and broadleaf weeds, add 450 mL of Companion in 50–100 L/ha of water. With chlorsulfuron, add 100 mL of Companion to 100 L of water for the control of broadleaf weeds. Use constant agitation.
Characteristics: Do not exceed the recommended rates of Companion, as too much may cause excessive run-off, reducing effectiveness of the herbicide.

Dazomet

Trade name: Basamid.
Chemical family: Dithiocarbamate.
Crop and non-crop registrations: Field and greenhouse vegetable seedbeds for eggplant, lettuce, pepper and tomato; fall treatment only of tobacco greenhouse seedbeds; field and greenhouse seed and planting beds for annual flowers; turf seedbeds.
Sensitive weeds: Most germinating weed seeds.

Uptake and translocation: Breaks down on contact with soil moisture and releases toxic gases that control germinating weed seeds.
Basis of selectivity: Non-selective. Chemical must be completely dissipated from the seedbed before planting or injury may occur. Breaks down on contact with soil moisture and releases toxic gases that control germinating weed seeds.
Application methods: Apply granular product to a well-worked seedbed and incorporate evenly. Seal soil immediately after incorporation by rolling and flooding or by covering with heavy polyethylene plastic and sealing edges. After waiting 10–40 days, depending on soil temperature, aerate the soil. Conduct a safety germination test before using treated soil. Do not use when soil temperature is below 6°C.
Residual activity: Depends on the rate applied, soil moisture and soil temperature. The gases are toxic to all growing plants, and a safety germination test must be carried out to determine if the soil is safe for planting.
Characteristics: Also controls unencysted nematodes and soil fungi.

Enhance

Type of adjuvant: Cationic surfactant with an additional non-ionic component.
Chemical composition: Mixture of tallow fatty acid amine ethoxylate and nonylphenoxy polyethoxy ethanol.
Registered uses: Season-long control of quack grass at low rate of glyphosate. For use with post-emergent applications of imazethapyr in soybeans.
Benefit: Improves consistency of performance, particularly at high-water volumes and under stressful growing conditions.
Mode of action: Improves leaf wetting and adhesion; increases overall penetration resulting in enhanced uptake of glyphosate.
Mixing: Half-fill the sprayer tank with clean water then add the required amount of glyphosate. While agitating, add the required amount of Enhance (0.5 L/ha in 100-200 L/ha of water) and complete filling the sprayer tank with water.

Fluazifop-p-butyl

Trade name: Fusilade II, Venture L
Chemical family: Aryloxy-phenoxypropionate.
Crop and non-crop registrations: Flax, canola, soybeans, sugar beets, sunflowers, tobacco, forage legumes (alfalfa, red clover and bird's-foot trefoil), cabbage, broccoli, brussels sprouts, cauliflower, cucumber, onions, potatoes, rutabagas, tomatoes, highbush blueberries, raspberries, strawberries, non-grassy ornamental plants, poplars, shrubs, trees, apples, apricots, cherries, cranberries, peaches, pears and plums, forest and ornamental nurseries.
Sensitive weeds: Annual grass species, volunteer corn, wheat, barley and quack grass.
Uptake and translocation: Absorbed primarily by leaves. Translocated to roots and rhizomes.
Basis of selectivity: Metabolism by tolerant species.
Application methods: Post-emergence. Apply when grasses are actively growing and annual grasses are in the 2-5-leaf stage and quack grass is in the 3-5-leaf stage.
Residual activity: Essentially none.
Characteristics: Preplant tillage to break up rhizomes improves control of quack grass. Except as noted on the label, broadleaf herbicides should be applied separately at least 3 days after fluazifop-p-butyl. Do not cultivate for 5 days after applying fluazifop-p-butyl. When plants are stressed (lack of moisture, excessive humidity, low temperature and very low relative humidity), fluazifop-p-butyl is less effective. Regrowth by tillering may occur if application is made under any of the above conditions. Since there is no residual activity, a new flush of weeds may emerge after the first flush has been controlled.

Frigate

Type of adjuvant: Cationic surfactant.
Chemical composition: Mixture of ethoxylated long-chain fatty amines.
Registered uses: Season-long control of quack grass at the lower rate of glyphosate (0.84 kg/ha) when applied with a water volume of 150-300 L/ha.
Benefit: More consistent season-long control of quack grass at low rate of glyphosate.
Mode of action: Improves wetting of foliage and enhances uptake of glyphosate.
Mixing: Add glyphosate to the required amount of water in the spray tank under agitation; then add Frigate at 0.5 L/100 L of spray mix. When water temperature is less than 5°C, mix Frigate with an equal volume of warm water before adding to spray tank.

Fumigants

See metam sodium, methyl isothiocyanate/dichloropropene, methyl isothiocyanate/dichloropropene/chloropicrin. See also sections on using fumigants on page 41 and page 53.

Glyphosate TMS

Trade name: Touchdown 480. See glyphosate.

Glyphosate

Trade names: Credit, Clear-It 1, Clear-It 2, Clear-It 3, Expedite Grass & Weed, E-Z-Ject, Glyfos, Laredo, Maverick, Renegade, Roundup, Roundup Dry, Roundup L & G, Roundup Transorb, Touchdown 480, Touchdown 600, Vantage, Vantage Plus,Vision, Wrangler.

Chemical family: Amino acid.

Crop and non-crop registrations: Credit, Glyfos, Laredo, Renegade, Roundup, Roundup Transorb, Vantage, Vantage Plus, Wrangler — preplant or post-harvest with no cropping restrictions; preharvest in wheat, barley, soybeans, canola, flax, lentils, peas and forages.

Touchdown 480–preharvest use in canola, barley, field beans, field peas, soybeans and wheat.

Roundup, Roundup Transorb, Vantage, Vantage Plus —in-crop uses in Roundup Ready crops; directed applications in ginseng, cherries, grapes, apples, pears, plums, and peaches and in strawberries as wiper or spot treatment.

Non-crop registrations: Expedite Grass & Weed, Roundup — brush control, turf renovation, chemical mowing, directed application in woody nursery stock, roadsides and shelterbelts.

Roundup—asparagus.

E-Z-Ject -- selective woody brush and tree control.

Vision — silvicultural site preparation, conifer release, forest tree plantings, forest tree nurseries.

Sensitive weeds: Annual grasses, perennial weeds (quack grass, Canada thistle, sow thistle, field bindweed, milkweed, cattails, nut sedge, poison ivy, etc.), brush (birch, alder, poplar, raspberry, willow and maple).

Uptake and translocation: Absorbed through foliage and translocated throughout the plant.

Basis of selectivity: Non-selective for agricultural crops. Conifers are tolerant at some stages but the basis has not been established.

Application methods: Post-emergence, usually at the bud-to-bloom stage of growth for most perennial weeds. Canada thistle should be at least in early flower bud, milkweed at flower bud, and bindweed at full flower. Quack grass can be treated in the spring or fall when it is actively growing with at least 3-4 new leaves on each emerged shoot. In the fall, remove crop refuse but do not till prior to application. Fall or spring tillage prior to spring application may reduce control. Wait at least 3–5 days after application before working the area. For maximum control, it is advisable to till before the quack grass turns completely brown. Glyphosate can be applied with boom equipment, knapsack sprayers and high-volume equipment for agricultural and non-crop uses. Backpack mist blowers may be used for silvicultural site preparation and roadside brush control only. Aerial applications may be used for silvicultural site preparation and conifer release only. Glyphosate can also be applied, with selective equipment, for non-crop areas, tree plantings, grapes and orchards. Regardless of application method, do not allow herbicide solution to contact green foliage or green bark of crop or other desirable plants. Remove all suckers from the trunks of desirable trees before spraying.

Residual activity: None. Crops can be planted or seeded directly into treated areas following application. Other herbicides are required to control weeds emerging after the application.

Characteristics: Rainfall within 6 hours after application or heavy frost within 24 hours may reduce control. Roundup Transorb is rainfast as soon as 4 hours after applicaiton.

Metam sodium

Trade name: Vapam

Chemical family: Thiocarbamate.

Crop and non-crop registrations: Field and greenhouse seedbeds; field replant sites of fruits, vegetables, tobacco, ornamentals, and forest tree stock.

Sensitive weeds: Most scarified weed seeds and fleshy vegetative parts including rhizomes and germinating seedlings.

Basis of selectivity: Most plant parts are sensitive. Crops are not planted until all fumigant has dissipated from the soil. With moisture, methyl isothiocyanate gas is released. This kills most scarified seeds and fleshy vegetative parts including rhizomes and germinating seedlings.

Application methods: Apply uniformly using injectors, water or other incorporation tools to carry the product to the desired soil depth. May be applied via the irrigation system. No gas-proof cover is required unless the soil is very porous; however, a sprinkler application of water should be used to provide a surface "water seal."

Residual activity: 10–40 days depending on soil temperature and the amount of organic matter present in the soil. Persistence is greatest at low temperatures and high levels of organic matter. Planting may take place 12–16 days after the treatment and following a lettuce seedling bioassay that indicates no injury.
Characteristics: Also controls nematodes, soil fungi and soil insects. All traces of toxic gases must be dissipated from the treated soil before planting or plant injury may occur.

Methyl isothiocyanate/ Dichloropropene

Trade name: Vorlex Plus.
Chemical family: Thiocarbamate.
Crop and non-crop registrations: Preplant treatment in both field and greenhouse soils to be planted to ornamental plants such as flowers and evergreens; vegetables such as celery, lettuce, beets, tomatoes, eggplant, beans, melons, onions, asparagus, and squash; field crops such as tobacco, sugar beets, potatoes, ginseng; small fruits such as strawberries.
Sensitive weeds: All growing weed seedlings within the fumigated zone. Non-germinated seeds or established weeds may not be controlled.
Basis of selectivity: Non-selective. Gas is toxic to most young, green plant tissues.
Application methods: Injected into the soil 15–20 cm deep using special application equipment. The soil surface is sealed by surface irrigation or by physically compacting the soil surface. Cultivation of the fumigated soil after the desired period of time allows the gas to escape.
Residual activity: Varies with soil type but usually 4–6 weeks if left undisturbed. Always check the soil for fumigant, using the lettuce seedling bioassay, before planting a crop in it.
Characteristics: Also controls fungal diseases and unencysted nematodes.

Methyl isothiocyanate/Dichloropropene/ Chloropicrin

Trade name: Vorlex Plus CP.
Characteristics: Chloropicrin provides added disease control to the mixture. See notes on methyl isothiocynanate/dichloropropene.

Napropamide

Trade name: Devrinol 50 DF, Devrinol 50 WP, Devrinol 10G.
Chemical family: Amide.
Crop and non-crop registrations: Asparagus, cole crops (cabbage, broccoli, cauliflower, Chinese broccoli, Chinese mustard greens, Chinese nappa cabbage, Chinese radish), garlic, kohlrabi, peppers, pumpkin, squash, fuzzy squash, rutabagas, tomatoes, tobacco, raspberries, blackberries, cultivated lowbush blueberries, established highbush blueberries, boysenberries, cranberries, loganberries, newly planted or established strawberries, apples, grapes, peaches and pears, newly transplanted or established ornamentals, woody nursery stock, forest tree stock and container-grown ornamentals (see label for species). With simazine or with terbacil on new plantings of apples, apricots, cherries, plums, peaches and pears.
Sensitive weeds: Many annual weeds including crab grass, barnyard grass, annual bluegrass, foxtails, sandbur, wild oats, goose grass, chickweed, groundsel, redroot pigweed, lamb's quarters, purslane, prostrate knotweed, pineapple weed and prickly lettuce.
Uptake and translocation: Absorbed through the roots of germinating weeds. Translocated upward through seedling.
Basis of selectivity: Metabolized by tolerant species. Root growth of germinating seedlings is inhibited. Established plants are not affected because of placement selectivity.
Application methods: May be applied preplant-incorporated using water as the carrier. Incorporation should be uniform and the chemical should be at a depth of 2.5–5 cm, using irrigation or proper incorporation equipment (e.g., tandem discs or field cultivator with sweep teeth) followed by a levelling device. On established crops, apply to a weed-free soil surface. Irrigate in if no rainfall occurs within 7 days after application in spring or fall or within 2 days after application in summer. Irrigate with sufficient water to wet the soil to a depth of 5–10 cm (about 7 mm of rain). For post-plant application in tobacco, apply in 25 cm band over the row. Cross-disc or cross-plough after harvest to dilute soil residue before planting cover crop.
Residual activity: Provides season-long weed control if properly incorporated. Deep ploughing minimizes any carryover effect.
Characteristics: Does not control germinated weeds. Resists leaching. To avoid injury to crops not registered for use with napropamide, do not plant until 12 months after the last napropamide application.

Surfactants

See Agral 90, AG-Surf, Companion, Enhance, Frigate.

Table 5-1. Weed control in flue-cured tobacco

Weed	generic name Trade Name (formulation)	Rate active product/ha	Product/ac	
Preplant				
Dandelions, quack grass and many other perennial grasses, annual weeds, rye and wheat cover crops, and volunteer cereals	glyphosate	0.9–2.52 kg	–	For perennial grass control, apply to actively growing plants with at least 3–4 new leaves. The low rate (2.5 L/ha or 1 L/ac) provides a minimum of one season control. Higher rates (4.75–7 L/ha or 1.9–2.8 L/ac) provide longer term control. For dandelion control, apply 2.5 L/ha (1 L/ac) if 15 cm or less in diameter and 3.5–5 L/ha (1.4–2 L/ac) if larger than 15 cm.
	Roundup Transorb (360g/L)	2.5–7 L	1–2.8 L	
	glyphosate TMS	0.825–2.31 kg	–	
	Touchdown 480 (330 g/L)	2.5–7 L	1–2.8 L	
Emerged annual broadleaf weeds and grasses, including rye or wheat cover crops and volunteer cereals	glyphosate	0.27–1.26 kg	–	See product labels for details. Glyphosate can be applied to actively growing weeds in the fall or spring before any crop emerges. Only weeds emerged at application time will be controlled. You then need to control weeds that germinate later with other weed control programs. See product label for rates for annual weeds. The low rate must be applied 50–100 L/ha water (20–40 L/ac). Apply the low rate plus a surfactant if greater volumes of water are used. Higher rates may be applied in 100–300 L/ha water (40–120 L/ac).
	Roundup Transorb (360 g/L)	0.75–3.5 L	0.3–1.4 L	
	glyphosate TMS	0.249–1.155 kg	–	
	Touchdown 480 (330 g/L)	0.75–3.5 L	0.3–1.4 L	
Other perennial weeds, including Canada thistle, milkweed, bindweed, dogbane and sow thistle	glyphosate	2.52–4.32 kg	–	Canada thistle and sow thistle should be at least in early bud, milkweed at bud, bindweed at full flower, and dogbane past full bloom for best results. All species should be actively growing at application time. When conditions are good allow 5–7 days translocation time after application before doing any tillage. If cool temperatures follow application, allow more time for translocation to be completed before disturbing treated weeds.
	Roundup Transorb (360 g/L)	7–12 L	2.8–4.8 L	
	glyphosate TMS	2.31–3.96 kg	–	
	Touchdown 480 (330 g/L)	7–12 L	2.8–4.8 L	
Post transplant				
Emerged annual grasses, wild proso millet, wild oats, volunteer corn and volunteer cereals	fluazifop-p-butyl	0.075–0.125 kg	–	May be applied up to 45 days before harvest. If applied in a band over tobacco plants, adjust the rate accordingly. Apply in 150–300 L/ha (60–120 L/ac) water.
	Fusilade II, Venture L (125 g/L)	0.6–1 L	0.24–0.4 L	
Germinating annual weeds	napropamide	1.125–2.25 kg	–	Apply immediately following transplanting in a 25–30 cm band over the transplants. Adjust the rate accordingly when applying a band. Use lower rates on lighter soils. For best results, lightly incorporate or apply irrigation if rainfall does not occur within 2 days of application. After harvest, work the soil at right angles to the rows to prevent injury to succeeding crops. Small grains may be seeded in the fall to prevent soil erosion. These grains may be stunted but not otherwise affected. Apply in 150–300 L/ha (60–120 L/ac) water.
	Devrinol DF (50 DF)	2.25–4.5 kg	0.9–1.8 kg	

6. Field Production

Cultural practices

Time of planting and plant population

The tobacco-growing season is shorter in Ontario than in many other areas of the world. Well-timed planting is essential to take advantage of every day. Long-term studies show that tobacco planted between May 18 and 24 usually has the best yield and quality. Tobacco planted in June is often of lesser quality and lower yield.

The most desirable plant population varies from farm to farm, depending mainly on soil fertility.

A suitable population for most farms is a range of 15,377–17,614 plants/ha (6,223–7,128 plants/ac). Slightly higher yields may be obtained with higher populations but this advantage may be offset by the added costs of handling more leaves. Also, as plant population is increased, there is a tendency to produce a thinner leaf that may be more susceptible to weather fleck. As row width is increased up to 122 cm (48 in.), yield tends to decrease.

The outlined area of Table 6-1. shows recommended plant spacings for tobacco.

Table 6-1. Plant populations per hectare and acre

Row width		Spacing within the row							
		cm: 41	46	51	53	56	58	61	66
cm	in.	in.: 16	18	20	21	22	23	24	26
102		24,219	21,528	19,373	18,453	17,614	16,848	16,146	14,905
	40	9,801	8,712	7,840	7,468	7,128	6,818	6,534	6,032
107		23,065	20,501	18,451	17,574	16,776	16,045	15,377	14,194
	42	9,334	8,297	7,467	7,112	6,789	6,493	6,223	5,744
112		22,017	19,570	17,614	16,773	16,012	15,207	14,678	13,549
	44	8,910	7,920	7,128	6,788	6,480	6,154	5,940	5,483
117		21,061	18,721	16,848	16,047	15,316	14,651	14,041	12,958
	46	8,523	7,576	6,818	6,494	6,198	5,929	5,682	5,244
122		20,184	17,940	16,146	15,392	14,678	14,041	13,455	12,420
	48	8,168	7,260	6,534	6,229	5,940	5,682	5,445	5,026

Irrigation

Any time the plant spends in a wilted, non-productive state can negatively affect the crop's final growth and development. Irrigating in the right amount at the right time is important.

You need a permit to take more than 50,000 L (11,000 gal) of water from ground and surface sources in 1 day. For more information, contact the nearest Ontario Ministry of the Environment office or you can download the application at www.ene.gov.on.ca/envision/gp/.

When to irrigate

Moisture stress reduces the photosynthetic capacity of a tobacco leaf before any physical symptoms, such as wilting, appear. The amount of water required is much greater at temperatures above 28°C (82°F) or during periods of low relative humidity.

Moisture requirements are especially critical during the following periods (listed in order of importance):

- just before topping until the tip leaves have fully grown out

- the rapid vegetative stage of growth from late June until just before topping
- harvest, especially if higher rates of nitrogen fertilizer have been used.

Base your decision to irrigate on soil or plant indicators or both. Soil moisture content, which should be kept at or above 6% by weight, can be determined by oven drying. Take a representative sample (15–20 cores, depending on field size) of the top 45 cm (18 in.) of soil between the tobacco rows. Mix it thoroughly, discarding any large plant debris. Weigh out exactly 1.0 kg (wet weight) of the soil and spread it out on a cookie sheet. Oven dry it at 105°C (220°F) for 12 hours. Allow it to cool and weigh it (dry weight). To calculate the soil moisture content subtract the dry weight from the wet weight, divide by the wet weight and multiply by 100.

$$\frac{\text{wet weight} - \text{dry weight}}{\text{wet weight}} \times 100 = \text{\% moisture content by weight}$$

Leaf wilting indicates moisture stress. Wilting depends on temperature and on relative humidity. In June or early July, a rapidly growing plant wilts in the afternoon on a clear, hot day, even with adequate soil moisture. On a clear, hot day irrigation may be beneficial if the lower part of the plant is wilting by late morning. Judging irrigation requirements based on plant indicators requires considerable experience and attention to details such as stage of plant growth, time of year, temperature and relative humidity.

Rate of water application and amount

The rate of water application must be low enough to let the water soak into the soil. Otherwise surface water drains to the low spots in the field and almost certainly causes movement of nutrients and localized leaching. Tobacco soils have relatively high infiltration rates, ranging from 0.75–2.3 cm/hr (0.3–0.9 in./hr). However, the surface area of soil available for water to soak in is greatly reduced by hilling. As well, plant leaves tend to direct some of the water to the area between the rows. As a result, application rates in the range of 0.75–1.2 cm/hr (0.3–0.5 in./hr) are typically all the soil can handle.

The amount of water that can be safely and efficiently applied depends on the soil's water-holding capacity, the initial moisture content, the depth of soil to be moistened and the rate and uniformity of water application.

On sandy soil, the optimum amount of water is between 2 cm (0.8 in.) and 4 cm (1.6 in.). In hot, dry weather, moisture in the upper 10 cm (4 in.) is easily and quickly lost to surface evaporation. An irrigation that wets only to this depth provides too little water for too short a time. For this reason, water applications less than 2 cm on a sandy soil are inefficient.

Applications of more than 4 cm wet the soil below the 45 cm (18 in.) depth, which is below the zone of soil containing the greatest concentration of tobacco roots. As a result, the plant is not capable of absorbing enough moisture and nutrients from this depth to support the leaves at full photosynthetic capacity, even though moisture held from 45 cm and below is well protected from surface evaporation by the dry soil above.

Heavy irrigations, at worst, result in localized puddling and leaching and, at best, extend the time between irrigations only slightly.

For more information on irrigation refer to OMAF Factsheet, *Tobacco Irrigation with Stationary and Travelling Gun Sprinklers*, Order No. 93–083.

Topping

Time and height of topping have a major influence on tobacco quality, yield, curability and chemical composition.

Time

The ideal time for topping is at the stretch-bud stage, about 1 week before the first flower. Yield is reduced up to 27.5 kg/ha (25 lbs/ac) each day that topping is delayed beyond stretch-bud. Earlier topping may provide an additional yield advantage, but it is more difficult to judge topping height.

Degree of leaf maturity, ease of curing and cured quality increase with time in the field after topping. It is important to produce a crop that can be topped early in the season and at an early stage.

Topping all plants at the same time promotes uniform maturity. Top more advanced plants at the ideal stretch-bud stage and bud out later plants, rather than delaying topping until all or most plants have stretched.

Height

Maturity of the upper leaves is enhanced by topping down so that a good-sized tip leaf is produced. In deciding where to top it is important to consider the date and how that may influence the time for tip leaf development. Consider also other factors such as variety, fertility and rainfall pattern. Present varieties are normally capable of producing 16–18 mature, harvestable leaves. Any yield advantage from higher topping is likely offset by lower value grades resulting from less mature tobacco.

Sucker control

The products listed in *Table 6-2. Litres of sucker control per hectare* may be applied before or after topping. Generally, an application during the early-to-late-bud stage is best.

Table 6-2. Litres of sucker control per hectare

	Litres of product		
	Before topping	After topping	Litres of water/ha
Chiptac	17	20	450
Delete	17	20	450
Emtrol	20	22	450
Emtrol Ten	17	20	450
Gold Leaf C-10	17	20	450
Pfizol 10	17	20	450

All the products listed may be used on flue-cured tobacco. Refer to the product label for use on other tobacco types.

Normally one application is enough. But conditions such as an uneven crop or poor timing may reduce the effectiveness of the first application. In this case, a second application 5–7 days after the first may be beneficial.

Directions for use vary somewhat from one product to another. Read the label carefully and follow all directions and precautions. Improper mixing, poor timing, boom pressures above 138 kPa (20 psi), and spraying during windy or excessively hot weather can damage the crop. A lower rate of sucker control may be required on very tender tobacco.

Disease control

Field stunting of tobacco: nematodes and black root rot

Root-lesion nematodes and black root rot are the main causes of stunting. Occasionally, a combination of both diseases occurs. Or a third factor, as yet undefined, may be involved.

Caution

Higher than recommended rates of sucker control can cause deep burn in the leaf axil. This may result in excessive and rapid sucker development from non-sucker tissue. Under some conditions, a deep burn can also lead to weakness at the point of leaf attachment, resulting in leaf drop, especially in large tobacco.

Nematodes are most likely to occur in sufficiently high populations to cause stunting on well-drained, medium to light tobacco soils. Nematode damage is characterized by the appearance, in late June or July, of patches of stunted plants that tend to wilt, particularly at midday. Root systems are usually quite small, and you may see brown areas on the roots. In severe cases, the plants remain stunted throughout the season and the yield is greatly reduced. In milder cases, plants may recover by midsummer but mature late.

Black root rot is more prevalent on heavy or poorly-drained tobacco soils and during cool, wet seasons. Damage is usually more severe where the crop sequence is tobacco following tobacco. Under severe conditions, black root rot stunts tobacco early in the season and delays maturity, resulting in reduced yield and quality.

The flue-cured tobacco varieties AC Gayed and CT 681 are highly resistant to black root rot. See Chapter 3, "Recommended Varieties." Other flue-cured tobacco varieties have an intermediate tolerance to black root rot.

Help prevent the build-up of black root rot in the soil with a crop rotation such as rye-tobacco or wheat-tobacco. For flue-cured tobacco on heavy or

poorly-drained soils, a corn-tobacco rotation may reduce black root rot.

Stop!

Before using any pesticide read Chapter 1 and follow all precautions and recommendations.

Control

Several soil fumigants can control nematodes and help reduce damage from black root rot. In the spring, about three weeks before planting, these materials must be injected into the soil about 15 cm (6 in.) deep.

Nematodes

Where nematodes are the main problem, use one of the treatments in *Table 6-3. Treatments for nematode control*. The rates on the low side of the range are the minimum required for nematode control.

Table 6-3. Treatments for nematode control

	Row	
	L/ha (107 cm rows)	*mL/100 m of row
Telone II	75–90	803–963
Vapam	65–85	696–910
Vorlex Plus	28–40	300–428

* mL/100 m of row remains the same regardless of row width

Black root rot

Where black root rot or black root rot along with nematodes is the problem, use the treatments in *Table 6-4. Multi-purpose fumigant treatments*. They provide satisfactory nematode control and at the higher rates may help reduce black root rot damage.

Table 6-4. Multi-purpose fumigant treatments

	Row	
	L/ha (107 cm rows)	*mL/100 m of row
Telone C-17	75–100	803–1,070
Vorlex Plus	56–90	599–963
Chloropicrin 100	28	280

* mL/100 m of row remains the same regardless of row width

Fumigants containing chloropicrin (Telone C-17 and Chloropicrin 100) are more effective than other fumigants in reducing black root rot.

The rate of application should vary within the recommended ranges according to the likely severity of the black root rot. Account for contributing factors such as the field history of black root rot, cropping sequence, type of soil and tolerance of variety to be grown.

Fumigant damage

Tobacco plants can be killed or severely stunted if the fumigant is still in the soil at planting. The danger of fumigant remaining in the soil is greatest in low, poorly drained areas or in heavy tobacco soil. In these soils, injecting the fumigant to a shallow depth of 10–15 cm should help. Exercise caution with any tobacco soil, especially when using high rates of fumigant or when cool, wet conditions prevail between fumigating and planting.

A week before transplanting, check for the odour of fumigant in several places in the soil near the point of injection. If you detect the fumigant odour where the field has been row-fumigated, open the hills with a single chisel or cultivator tooth. Reopening may be necessary if heavy rainfall and cool temperatures occur after the initial opening. Where the fumigant has been broadcast, cultivate the soil to the depth of the treatment zone.

Sore shin

Each year sore shin affects some plants soon after transplanting. Affected plants show brown or black discoloured areas on the stem near ground level. The extent of the lesion varies, sometimes being limited to one side or in severe cases completely girdling the stem. Some of the plants die soon after planting while others develop normally until later in the season when the wind may break them off.

Control

The disease has been noticed under a wide range of moisture and temperature conditions. This may be attributed to the different strains of the fungus causing sore shin. There is no recommended chemical control.

Weather fleck

Weather fleck, a leaf disorder of flue-cured tobacco, is caused by certain oxidants in the air, mainly ozone. Oxidants damage the leaf tissue and cause small, irregularly shaped spots to develop. The spots are generally less than 4 mm in diameter. The spots are initially black but later turn brown and

eventually greyish-white. The most serious losses generally occur just before or during the early part of harvest when the lower leaves are maturing.

Control

Present control measures involve cultural practices and choosing tolerant varieties. Cultural practices such as proper plant spacing (page 50), proper irrigation, well-balanced fertilization, early topping and clean suckering help produce a leaf that is less susceptible to weather fleck. For tolerance levels of varieties, see "Recommended Varieties" on page 30.

Frenching

This disease appears occasionally, especially on marginal tobacco land. Severely affected plants are stunted, and the leaves become thick and straplike. Sometimes only the suckers are affected.

Control

The tendency to french is related to soil conditions. Improved drainage and good fertilization practices may help prevent this disease.

Blue Mold

Infected leaves initially show large yellow spots with greyish-blue mould on the undersurfaces. As these spots age they become brown and the dead tissue eventually drops out in the field or during curing.

Control

When needed, the Blue Mold Task Force will recommend additional preventive measures. Contact the OMAF Integrated Pest Management specialist (specialty crops) or tobacco specialist for information.

Aliette WDG and Acrobat MZ are recommended if Blue Mold is reported in Ontario tobacco crops. Ridomil is not recommended, since strains of Blue Mold resistant to Ridomil exist.

To take a proactive approach in reducing the risk of disease, you can follow the application techniques for Acrobat MZ or Aliette WDG. See *Table 6-5. Application of Aliette WDG* and *Table 6-6. Application of Acrobat MZ*.

Table 6-5. Application of Aliette WDG

Stage of tobacco	Amount of mixture sprayed	Amount of product applied	Nozzle number
Early plant growth: early to mid-June, up to 25 cm (10 in.) in plant height	112 L/ha (45 L/ac)	0.75 kg/ha (0.66 lb/ac)	minimum of 1 nozzle
Mid growth stage: late June to early July, from 25–36 cm (10–14 in.) in plant height	170 L/ha (69 L/ac)	1.125 kg/ha (1.0 lb/ac)	minimum of 1 nozzle
from 36–70 cm (14–28 in.) in plant height	315 L/ha (127 L/ac)	2.125 kg/ha (1.9 lb/ac)	minimum of 3 nozzles
Late growth stage: mid-July, 70 cm (28 in.) in plant height to topping stage	450–560 L/ha (182–227 L/ac)	3 kg/ha (2.67 lb/ac)	up to 5 nozzles

Use product at the recommended rate as outlined on the product label. Total product allowed per season is 10 kg/ha or 8.9 lb/ac. Do not apply within 5 days of harvest.

Table 6-6. Application of Acrobat MZ

Stage of tobacco	Amount of mixture sprayed	Amount of product applied	Nozzle number and arrangement*
Freshly transplanted tobacco (0–3 weeks after planting)	110 L/ha (45 L/ac)	0.49 kg/ha (0.44 lb/ac)	minimum of 2 nozzles (See Figure 6-1 on next page.)
Mid-sized tobacco (knee high)	220–330 L/ha (89–134 L/ac)	1–1.5 kg/ha (0.9–1.3 lb/ac)	5 nozzles (See Figure 6-2 on next page.)
Large-sized tobacco (waist high or taller)	440 to 560 L/ha (178–227 L/acre)	2 –2.5 kg/ha (1.8–2.2 lb/ac)	7 nozzles (See Figure 6-3 on next page.)

Use product at the recommended rate as outlined on the product label. Total product allowed per season is 5 kg/ha or 4.45 lb/ac. Do not apply within 21 days of harvest.
*Spray configuration found to be effective.

Acrobat MZ and Aliette WDG are preventive products and should be used before infection occurs. Treating a crop once the disease is established is not as effective. After the first application of either product, more applications are required for effective protection. Follow the label regarding the pre-harvest intervals. A preventive spray program will not guarantee control of Blue Mold, but it should help reduce the amount of infection to a more manageable level if the disease occurs.

Factors to help prevent blue mold infection:

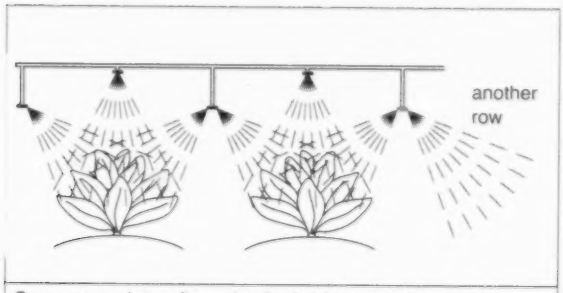
- Start spraying before Blue Mold infects the crop.
- Calibrate sprayer before applying the product.
- Use the proper nozzles and arrangements of nozzles for the stage of tobacco being treated to get full coverage of entire plant.
- Use the product at the recommended rates on the product label.

Application techniques

Thorough coverage of tobacco plants when applying fungicides can be obtained with the following application techniques when using a hydraulic-type sprayer, such as the Hahn Hi-Boy:

- Use a spray boom arrangement with a single nozzle centred over the tobacco row for early applications. See *Figure 6-1. Nozzle configuration for freshly transplanted tobacco.*

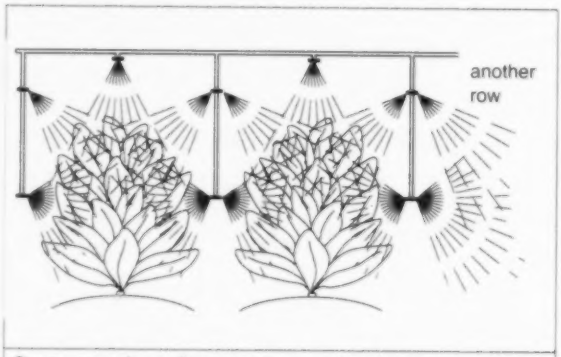
Figure 6-1. Nozzle configuration for freshly transplanted tobacco



Sprayer nozzle configuration for freshly transplated tobacco (0–3 weeks after planting).
Figure courtesy of BASF Canada Inc.

- In later applications use additional nozzles mounted on drop pipes, centred between the rows on either side of the centre nozzle, and aimed at plants on either side of the drop pipes. See *Figure 6-2. Nozzle configuration for mid-sized tobacco.*

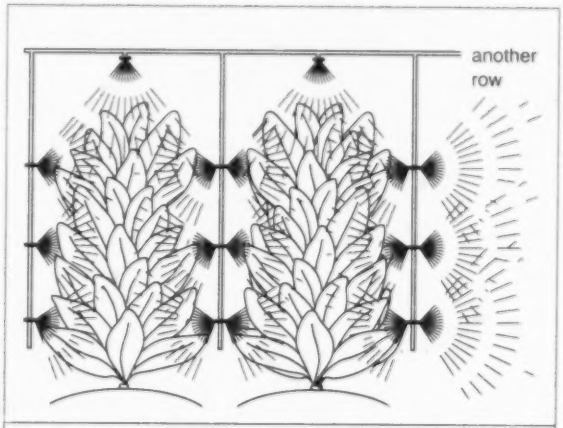
Figure 6-2. Nozzle configuration for mid-sized tobacco



Sprayer nozzle configuration for knee high plants.
Figure courtesy of BASF Canada Inc.

- Mount the drop nozzles on a swivel to allow small adjustments in mounting angle to get the best coverage at various growth stages. See *Figure 6-3. Nozzle configuration for large-sized tobacco.*

Figure 6-3. Nozzle configuration for large-sized tobacco



Sprayer nozzle configuration for waist-high or taller plants.
Figure courtesy of BASF Canada Inc.

Viral diseases

Tobacco mosaic

The tobacco mosaic virus is quite variable and so are the symptoms. The characteristic symptom is leaf mottling with yellow-green and dark green areas. The younger leaves are frequently blistered and malformed. The major damage is reduced yield and quality.

Control

Take the following preventive measures:

- Avoid smoking or using tobacco while working with seedlings in seedbeds or when transplanting. Wash hands before handling seedlings.
- Do not rotate tobacco after tobacco or tomatoes.
- Thoroughly wash any transplanting or cultivating machinery used previously for tomatoes.
- Do not cultivate when plants are wet.
- Rogue out diseased plants if they show virus symptoms within a few weeks after transplanting.
- Control weeds in greenhouses, fields and fencerows, as certain weeds may become infected with mosaic.

Tobacco veinal necrosis

This strain of Potato Virus Y (PVY^N) can be very destructive to tobacco. Symptoms include yellowing, mottling and puckering of leaf tissue accompanied by brown or black necrotic veins. Partial-to-complete death of individual leaves may occur. In severe cases, entire plants wither and die.

Aphids transmit the disease from infected solanaceous plants such as potatoes and ground cherry. The virus can only survive in living plant tissue, overwintering mainly in potato tubers and possibly in ground cherry. It is not transmitted through tobacco seed.

Control

Aphid control procedures, as outlined in "Aphids" on page 58, are encouraged but will not likely stop the spread of PVY^N. Sources of the virus need to be eliminated.

Commercial and home garden potato producers must use only foundation or certified seed.

Destroy volunteer potato growth from the previous year in fields and cull piles. If possible, do not grow potatoes near or in rotation with tobacco. Control ground cherry, most often found in surrounding fencerows and other uncultivated areas.

Other viral diseases

Several other diseases, including ringspot, cucumber mosaic, etch and streak occasionally infect tobacco but rarely cause significant losses.

For more information on diseases affecting tobacco, refer to Agriculture & Agri-Food Canada Publication 1641, *Tobacco Diseases* and OMAF Factsheets, *Blue Mold of Tobacco*, Order No. 83–068 and *Tobacco Veinal Necrosis Strain of Potato Virus Y (PVY^N)*, Order No. 91–001.

Insect control

Cutworms

Spray treatments should be applied during late afternoon or in the evening, using at least 220 L/ha of water.

Cutworms may migrate to tobacco fields from bordering areas. Treat these areas with Lorsban, Pyrinex, Ripcord, Decis, Pounce or Cymbush. Follow the label directions and precautions.

Cutworms can be treated in the cover crop, the soil or the planting water.

Cover crop

Treating the cover crop is most effective when done soon after the cutworms have hatched, usually in mid-to-late April. When the cover crop is 10–15 cm (4–6 in.) high the cutworms are at the right stage for best control. Treat 4–5 days before plowing. See *Table 6-7. Treatment for cutworms—cover crop* for treatment.

Table 6-7. Treatment for cutworms—cover crop

Lorsban 4E or Pyrinex 480 EC	1.2 L/ha
Ripcord 400 EC	90 mL/ha
Decis 5 EC	100 mL/ha
Pounce 384 EC	175 mL/ha
Cymbush 250 EC	140 mL/ha

Soil

The materials listed in *Table 6-8. Treatment for cutworms—soil* work best when the soil is moist. Use the higher rates when the top 2 cm or more of soil is dry. Treat 1–3 weeks before planting, preferably before mid-May.

Table 6-8. Treatment for cutworms—soil

Lorsban 4E or Pyrinex 480 EC	2.4–4.8 L/ha
Ripcord 400 EC	175–350 mL/ha
Decis 5 EC	200–400 mL/ha
Pounce 384 EC	175–350 mL/ha
Cymbush 250 EC	280 mL/ha

Do not disturb the soil for at least 5 days after applying Ripcord, Decis, Pounce and Cymbush since mixing with the soil reduces their effectiveness.

Lorsban or Pyrinex is better left on the soil surface although shallow incorporation (2–3 cm) is not likely to reduce effectiveness. Deep incorporation, however, might lower their activity.

Planting water

Use Orthene 75% SP—1.1 kg/ha in at least 1,200 L/ha of planting water.

At or after planting

Insecticides may be overall or band applied at or after planting. The rates in *Table 6-9. Treatment for cutworms— at or after planting* are per treated hectare. When band spraying, a treated hectare is not the same as a crop hectare. For example, one treated hectare would be equivalent to 4 crop hectares when spraying a 25 cm band on a 1 m row spacing.

Table 6-9. Treatment for cutworms— at or after planting

	Amount per treated ha	Pre-harvest interval (days)
Ripcord 400 EC	175 mL	60
Orthene 75% SP	1.5 kg	3
Decis 5 EC	200 mL	70
Pounce 384 EC	175 mL	55
Cymbush 250 EC	280 mL	*

* Use only at planting

If cutworm damage occurs after planting, treat it when at least 5% of the plants show signs of cutworm feeding.

For cutworm control in late June and July use only Orthene. The treatment-to-harvest intervals for Ripcord (60 days), Decis (70 days) and Pounce (55 days) make these materials useable for only a short time after planting.

Alternate the use of pyrethroids (Ripcord, Decis, Pounce and Cymbush) with Lorsban or Pyrinex for preplanting and Orthene for post-planting treatments. This practice reduces the risk of cutworms becoming resistant to these materials.

Stop!

Before using any pesticide read Chapter 1 and follow all precautions and recommendations. Observe the interval between foliar treatment and harvest.

Wireworms

Use one of the following planting water treatments:

Orthene 75% SP	1.1 kg/ha in at least 1,200 L/ha of planting water
Lindane 25% WP	28 g/180 L of planting water

Apply 170 mL of the Lindane planting water mixture per plant. With 107 x 61 cm spacing, you will need 2,600 L/ha.

Stir mixture frequently to reduce settling and drain the barrel occasionally to avoid overconcentration of the insecticide. Lindane may be used in combination with Diazinon in the planting water.

Caution

1. Do not combine Lorsban or Orthene with Lindane in the planting water.

2. Do not combine Diazinon, Lorsban or Orthene with starter fertilizer in the planting water.

3. Place band treatments of granular fertilizer 10 cm on each side of the tobacco row. Closer placement in combination with Diazinon, Lorsban or Orthene in the planting water may injure tobacco plants.

4. Avoid contact with planting water containing Lindane, Diazinon, Lorsban or Orthene.

Seed maggots

Well-hardened, sturdy transplants are less apt to be retarded by maggot feeding. Use one of the following planting water treatments:

Orthene 75% SP 1.1 kg/ha in at least 1,200 L/ha of planting water
Diazinon 50% WP 42 g/180 L of planting water
Lorsban 50% WP 25 g/180 L of planting water

Apply 170 mL of the Diazinon or Lorsban planting water mixture per plant. With 107 x 61 cm spacing you need 2,600 L/ha.

Stir planting water frequently to reduce settling and drain the barrel occasionally to prevent over-concentration of the insecticide. Diazinon may be used with Lindane in the planting water.

Tarnished plant bugs

Tarnished plant bugs occasionally infest tobacco fields in July. They feed on the leaves and injure the leaf midrib, causing the end of the leaf to wilt or break.

Use Dylox 420 EC–2.75 L/ha and allow 3 days between treatment and harvest.

Hornworms

Treatment is justified when the population averages 5 or more hornworms per 100 plants. Ground or aircraft applications are equally effective. Do not work in tobacco fields during application of chemical insecticides.

Observe the recommended pre-harvest interval (PHI) between treatment and harvest. You can handle tobacco treated with Thuricide HPC or Dipel immediately after treatment as these materials are not poisonous to people or animals.

Use one of the treatments in *Table 6-10. Treatment for hornworms* in enough water to provide adequate coverage. Repeat if necessary.

Hornworms stop eating immediately after feeding on tobacco treated with Thuricide HPC or Dipel. The larvae may remain alive after the treatment for up to 6 days without feeding.

Table 6-10. Treatment for hornworms

	Amount per ha	Preharvest interval (days)
Dipel	275 g	–
Thuricide HPC	1–1.5 L[1]	–
Orthene 75% SP	725 g	3
Dylox 420 EC	2.75 L	3
Sevin 50% WP	2.25 kg	3
Sevin 80% WP	1.50 kg	3
Sevin XLR Plus 480 Su	2.5 L	3
Lannate Liquid[2]	2.25 L	5

1 Use the higher rate when insect pressure is severe, large worms are present, or the foliage is abnormally rank and dense.
2 Minimum period before entering fields treated with Lannate is 24 hours.

Aphids

Early treatment of infested areas reduces the chance of a heavy and widespread aphid build-up. Starting in late June or early July, monitor fields carefully, especially near the edges. When at least 20% of the plants in an area have 5 or more groups of aphids on each upper leaf, treat the area.

Since it is especially important to treat the undersides of the leaves, application of non-systemic insecticides by aircraft may not be as effective as ground application. When treating for aphids with ground equipment, use at least 340 L/ha of water and thoroughly cover the upper part of the plant. Drop nozzles are essential for non-systemic insecticides (Malathion) and may improve the performance of systemic or partially systemic insecticides (Pirimor, Orthene and Lannate).

Use one of the products listed in *Table 6-11. Treatment for aphids* and observe the recommended pre-harvest interval (PHI) between treatment and harvest:

Table 6-11. Treatment for aphids

	Amount per ha	Pre-harvest interval (days)
Pirimor 50% WP or 50% DF	275–550 g[1]	14
Orthene 75% SP	750–1,100 g[1]	3
Lannate Liquid[2]	2.25 L	5
Malathion 50% EC[3]	2 L	7

1 Use the higher rate when a heavy infestation occurs throughout the field and when weather is hot and dry.
2 Minimum period before entering fields treated with Lannate is 24 hours.
3 Malathion is not effective at temperatures below 18°C.

Flea beetles

These small, shiny, black jumping beetles chew small holes in the lower leaves. They seldom cause enough damage to warrant treatment. If high populations are present, use one of the products in *Table 6-12. Treatment for flea beetles* and observe the recommended interval between treatment and harvest.

Table 6-12. Treatment for flea beetles

	Amount per ha	Pre-harvest interval (days)
Sevin 50% WP	2.25 kg	3
Sevin 80% WP	1.5 kg	3
Sevin XLR Plus 480 Su	2.5 L	3
Orthene 75% SP	725 g	3

7. Harvesting

The maturity of the leaves at harvest is one of the most important factors affecting final quality. For best results, all leaves should be mature in both age and colour. Leaves prematurely yellow because of nitrogen shortage and leaves that have not yet undergone any colour change because of an excess of nitrogen are not mature.

There is a tendency to start harvesting too soon, before the sand leaves are old enough. Research shows that sand leaves gain considerably in weight and quality when harvesting is delayed for 1–2 weeks. When delaying the harvest, it is essential to prevent the soil from drying out because quality reduction occurs at low soil-moisture levels.

Another reason to delay the harvesting of sand leaves is the cost of curing. Their light weight makes sand leaves more expensive to cure. If gains in yield and quality can be obtained by delaying the harvest, the cost of curing can be reduced.

The ease of curing and the quality of cured leaves depend on the maturity and uniformity of the leaves. Variation in colour between successive stalk positions decreases at higher stalk positions, and the rate of colour change during yellowing decreases. Fortunately, upper leaves generally stay in a yellowed, undried state without colour degeneration for a longer time than lower leaves.

Best results in curing are obtained by harvesting 2–3 leaves per plant from low and middle stalk positions over several weeks as the leaves mature. This allows 7 or 8 undertip and tip leaves to remain on the plants for the final 2 primings. Preferably, allow these upper leaves to mature and then harvest on 2 successive days. Too few leaves left on plants for the final priming increases potential problems with second growth.

Avoid harvesting during heavy rainfall or irrigation and for 2–3 days after. Otherwise curing usually is more difficult because the extra water prevents good air circulation and wilting. Also, curing costs are increased because more heat is needed to remove the extra water from the kiln. There is a good possibility of renewed nutrient uptake after rainfall. This may result in difficult and prolonged yellowing, the production of green or brown-coloured leaves and low overall quality.

Mechanical harvesters

In recent years, interest has been increasing in reducing harvest costs by using mechanical harvesters. These machines remove leaves in successive primings and deposit them at random (non-oriented) in large containers or bins for curing. Growers with automatic harvesters should make at least 5 passes to minimize the risk of mixing plant positions.

Although mechanical harvesters reduce labour costs, losses in yield quality may occur. Studies have revealed two potential sources of yield loss from mechanical harvesters. Leaf material is lost when broken leaves or butts of leaves are left on the stalk and when leaves or parts of leaves fall to the ground.

The second source of yield loss is in curing. Slower drying time for curing non-oriented leaves in bins can result in a greater weight loss than curing oriented leaves in racks or on laths.

8. Curing

Curing disorders

Green fixation

Temperatures higher than 43.3°C (110°F) for a few hours early in yellowing can cause complete green fixation. Green is also fixed at temperatures below 43.3°C if premature drying removes excess moisture from kilns. A relatively high level of moisture in the leaves is needed to maintain life and permit yellowing to proceed.

Green is highly undesirable and should be eliminated in curing even if this results in some darkening of leaf tissue.

Browning

The chief causes of browning are over-yellowing of leaves and excessive moisture loss during yellowing. The leaves must be alive to allow the chemical reactions responsible for yellowing to occur. After the leaves turn yellow, or wilt excessively, browning occurs unless the leaf tissue is dried to fix the colour and prevent further chemical change.

Browning is particularly prevalent when all the leaves are not equally mature at harvest. In such instances browning occurs in the mature leaves due to over-yellowing before the immature leaves are completely yellow.

Browning because of excessive moisture loss is particularly prevalent when leaves are immature or have second growth. Extended yellowing or yellowing at too high a temperature may cause excessive moisture loss in the leaf, particularly in the thinnest parts of the leaf, ie., the shoulders, tails and edges.

Chemical reactions responsible for yellowing and browning proceed more rapidly in the thin leaves from lower stalk positions than in the thick leaves from upper stalk positions. Therefore, the lower leaves must be dried more quickly on completion of yellowing. To prevent browning, leaves must be uniformly mature at harvest and be dried quickly in the colour-fixing phase.

The best rate of drying in the colour-fixing phase is achieved by increasing the temperature and reducing the relative humidity at the same time. The rate of drying may be too slow if the relative humidity is reduced quickly while the temperature is increased only slightly or not at all. Slow drying may also occur if the relative humidity changes little while the temperature is increased.

Too much reliance is often placed on an increased temperature to dry the leaves. This may cause a type of browning called scald. To prevent scald, base the rate of temperature increase on the rate of reduction in relative humidity or on the rate of increase in the difference between dry- and wet-bulb temperature readings. The faster this difference can be increased, the more rapidly the temperature can be advanced without causing scald.

Sponge

Sponge appears as a light brown to brown-mottled discolouration on the leaves. In contrast to browning, which appears as a solid colour, sponge is less intensive and lighter in colour although on upper stalk positions it may be relatively dark. In thin, bright leaves sponge may appear as grey.

Sponge occurs as a result of prolonged yellowing, too slow a rate of drying in colour fixing or exposure of leaves to alternate heating and cooling in yellowing. Sponge usually is prevalent with natural convection curing and is much less common with forced-air curing, particularly with the high-volume airflow associated with bulk curing.

Although sponged leaves are similar to leaves categorized as grey, they appear under different conditions than those causing grey leaf. The latter usually is caused by premature colour ripeness in

the field resulting from low nitrogen, micronutrient imbalance or improper use of Ethrel.

Splotching

Splotching appears as very dark brown spots or irregular-shaped areas during the latter part of the yellowing phase or in the early part of the colour-fixing phase. It is often referred to as moisture spot. Splotching occurs when condensed moisture is present on the leaves. It is the result of insufficient ventilation, improper use of ventilators and heavy loading of kilns. Severity, which can vary from a few small spots on some leaves to complete colour degeneration of whole leaves, depends on the amount of free moisture and time of exposure. To prevent splotching, follow recommended kiln loading and curing practices.

Scorch

Dry leaf tissue reddens or becomes scorched within a few hours if exposed to temperatures above 76.6°C (170°F). Leaves also become scorched if exposed to a final temperature above 71°C (160°F) for a prolonged period. Such exposure may be necessary to complete drying of midribs as a result of cool, windy weather with poorly insulated kilns or because of poor air distribution patterns. The latter may occur because of kiln structure or loading practices. Too much exhaust air ventilation at high temperatures can cause the burner to operate more frequently, producing scorched leaves with little increase in the speed of stem drying.

Leaf tissue is also prone to reddening if relative humidity levels are kept higher than normal during late colour-fixing and final drying, particularly if the leaves are thin. Since redness is undesirable, keep the upper temperature no higher than 71°C (160°F), insulate kilns, load uniformly, improve uniformity of air circulation and maintain recommended wet- and dry-bulb temperatures.

Small spots

Dark-coloured spots, similar in appearance to weather fleck, often appear on leaves during the yellowing phase. Like weather fleck, the spots are most prevalent on the lower leaves. They may occur at high levels of relative humidity in all parts of a kiln and with most types of curing systems and kilns.

Another spot appearing in yellowing is smaller than the previous type, can be black or green and can appear at all stalk positions. These small spots appear to be immature areas that are difficult to yellow at a low yellowing temperature. There usually is little or no evidence of such spots when leaves are yellowed within the recommended range of 35°C–40.6°C (95°F–105°F). The colour of these spots depends on relative humidity in yellowing. The spots are black at high relative humidity and greenish at low relative humidity.

Spots may also appear at upper stalk positions on leaves treated with ethylene gas, particularly if the relative humidity is maintained at a high level during and immediately after the gas generation period. The same conditions that give rise to discrete spotting in upper leaves may cause non-discrete browning of large areas of tissue on thinner leaves at low and middle stalk positions. Spotting is minimized when most of the leaves are yellowed at 35°C–40.6°C (95°F–105°F), when leaves are mature at harvest and when recommended wet- and dry-bulb temperature differences are maintained.

Runback

Runback is a band of darkened tissue along each side of the midrib. Occasionally it is seen along lateral and secondary veins as well. It occurs during late colour-fixing or early final drying if there is a substantial decrease in temperature when midribs and veins are drying and adjacent blade tissue is dry. The stem juices are absorbed by dry blade tissue, causing a dark discolouration. The condition can occur if the furnace is not working.

Disease control

Several fungal and bacterial organisms frequently infect leaves during the yellowing stage of curing.

Fungal pole rot

This type of pole rot, the most serious, is caused mainly by *Rhizopus arrhizus*. Infection by this fungus is enhanced by leaf injury from harvesting, tying or pinning and by high humidity accompanied by normal yellowing temperatures. Disease development is reduced and eventually arrested as the fungus is exposed to temperatures above 43°C (110°F). Spores of the fungus remain viable after the high heat of stem drying and may carry over from year to year on sticks and in kilns.

Control

Dependable control measures for this disease are not yet available, but damage can be reduced by following certain harvesting, curing and sanitation procedures.

> **Stop!**
>
> **Before using any pesticide read Chapter 1 and follow all precautions and recommendations.**

Harvesting and curing

Prolonged yellowing and restricted or non-uniform airflow favour pole rot. Uniformity in the ripeness of harvested tobacco and in loading sticks, racks or bins is very important. Do not overload kilns.

Procedures in curing that encourage early wilting are helpful in improving airflow. Some of these procedures include

- not starting the fan or burner in stick kilns until the day after filling, while being careful to monitor for any sign of overheating
- yellowing at as high a temperature as possible, up to 41°C (105°F)
- closing ventilators and flashing the yellowing temperature up to 48°C (118°F) and back down to the yellowing range within 1–2 hours.

Flash the temperature only when the tobacco first exposed to incoming air has proceeded to a point where it could be dried. Flashing at an earlier stage may cause green fixation.

Sanitation

Pole rot is a severe problem on some farms while others are relatively free of the disease. One reason may be the build-up of the fungus from previous years on sticks, racks, bins or in kilns.

There has been some success in reducing the problem by disinfecting sticks, racks, bins and kilns. Bundles of sticks may be dipped in a formaldehyde solution (1 L of Formalin to 25 L of water) for 1–5 minutes. A sodium hypochlorite solution (e.g., 1 L of bleach to 5 L of water), although slightly less effective, may be used instead of formaldehyde. Kilns can be treated with either solution.

Treatment, particularly with formaldehyde, of sticks or kilns should be done 4–6 weeks before harvest to allow harmful vapours to escape. After treatment, store sticks under cover in a well-ventilated area.

Another option is to use 1-Stroke Environ. Mix 1 L of 1-Stroke Environ in 250 L of water to make a 1:250 solution. Apply solution 2 months before using kilns or sticks, using one application a year. Spray the interior of the kiln and dip the sticks, thoroughly wetting all surfaces. Sticks should be soaked for 10 minutes. Allow kilns and sticks to air dry.

Aspergillus

Aspergillus is a fungal disease that causes a sooty-like deposit to form on the leaves. This deposit is spores of the fungus and can be black, green or yellow. When the cured leaves are rubbed, the deposit is similar to a fine dust. Tobacco can become infected with this fungus in the kiln.

Disease development can occur during the yellowing period when curing. Development typically stops after the yellowing period, but the spores remain alive even after exposure to the high drying temperatures used in curing. After curing and during storage, the fungus can develop further and cause significant damage.

Control

There are no chemical controls recommended for use in the field or during curing. Avoiding prolonged yellowing is the only control measure that can be used during curing.

Remove any remaining tobacco debris after the kiln is unloaded. This will eliminate one potential source for contaminating the next load of tobacco. *Aspergillus* can carry over in the kiln to next year. Treating kilns with a solution of formaldehyde or bleach 4–6 weeks before next year's harvest will kill the fungus. See sanitation procedures outlined under "Fungal pole rot" on page 63 for the rates of materials and method of application.

Using proper storage procedures as outlined under "Storage" on page 65 also helps minimize losses.

Bacterial soft rot

This disease, which originates in the field, develops during yellowing. Initially, it affects the midrib at the butt-end of the leaf and quickly spreads through the veins, causing a dark brown or black discolouration of the veins and adjacent tissue. If

spread continues, entire leaves rot and emit a foul odour.

The bacteria causing this disease infects plants in the field, often resulting in a condition known as hollow stalk. Infected leaves have a brown discolouration on the underside of the midrib. Infection can spread from these to other leaves in the kiln, especially when tobacco is harvested during wet weather and when there is too much relative humidity during yellowing.

Control

Rogue out diseased plants in the field and discard infected leaves when harvesting and kiln loading. Using proper harvesting, loading, and curing procedures as outlined under "Fungal pole rot" on page 63 helps minimize losses.

9. Storage

The main problem in storing tobacco for any length of time, especially from one year to the next, is damage from moulds and heating.

Spoilage is caused by excess moisture in the tobacco, taken up from the start of or during the storage period.

To minimize spoilage, tobacco should be packed on the dry side (less than 18% moisture) and be free of sand. When *Aspergillus* is present, casing the cured tobacco to 16% moisture content or less helps minimize further development of this fungus.

In most cases, facilities are not available to eliminate completely the effects of variations in humidity, so periodic inspections are essential. Inspect most frequently during and after prolonged periods of mild, damp weather in the fall and spring. In certain situations, using plastic over and under the tobacco can reduce the effect of variations in moisture in the surrounding air.

Tobacco tends to darken in storage. Certain grades such as bright and green may actually improve.

The location and type of storage facility can also affect spoilage. Kilns or barns sitting on well-drained soil where air movement is not hampered by trees, hills or other buildings should offer the safest storage. The ability to provide ventilation after periods of high humidity could be beneficial. When storing tobacco in kilns, running the fan periodically can help keep moisture levels down.

Tobacco in many standard kilns is exposed to wide variations in humidity. This may cause excessive darkening. There is also the risk of damage from moulds on the lower tiers.

Standard kilns, if reasonably tight and located in a high, dry area, can provide satisfactory storage. Removing the bottom 2 tiers and covering the floor with a plastic vapour barrier are good precautions.

Bulk kilns on cement pads can provide reasonably safe storage conditions for tobacco in racks, bins or bales, but certain precautions need to be taken. Spoilage can occur, and is most likely, in the bottom tier of racks because of damp conditions close to the cement. Insulated pads should provide drier conditions.

Inspect frequently for any increase in moisture and provide drier conditions when necessary. Exhaust vents should be tightly sealed to prevent any intake of rain or snow.

If bales are stored on the floor of bulk kilns, use a plastic vapour barrier on the floor. As a further precaution bales could be stored on top of empty racks installed on the bottom tier.

Do not pack bales tightly and preferably not more than 2 high. Damp conditions near cement floors can cause spoilage of the tobacco nearest the cement. In the pack barn, store tobacco on pallets with a plastic vapour barrier between the tobacco and the cement. Plastic could be laid on the cement floor with the pallet on top, or it could be laid on top of the pallet. In this case, provide some air circulation between the tobacco and plastic by means of boards, sticks or corrugated cardboard.

The plastic vapour barrier is a good precaution, even in barns where plastic has been laid under the cement. If bale stackers or other means of storing the tobacco at a considerable distance above the floor are available, the plastic vapour barrier is not needed. Covering the bales or piles with black plastic provides some protection from variations in humidity and other conditions that may lower quality.

Another problem can be contamination from an off-odour. This can be prevented easily by not storing anything with the tobacco that can produce an odour and by making sure the storage is free of odours before storing tobacco.

Insects are not likely to be a problem, but preventive measures need to be taken against rats and mice.

APPENDIX A: Ontario Ministry of Agriculture and Food Advisory Staff

Field office location	Staff	Commodity or discipline	Telephone	Fax and E-mail name@omaf.gov.on.ca
Brighton Resource Centre			**(613) 475-1630**	**(613) 475-3835**
95 Dundas St. E RR 3 Brighton K0K 1H0	Margaret Appleby	IPM systems	(613) 475-5850	margaret.appleby@
Delhi Southern Crop Protection and Food Research Centre			**(519) 582-7220**	**(519) 582-4504**
Schafer Rd. Box 186 Delhi N4B 2W9	Denise Beaton Tim McDowell	IPM — specialty crops Tobacco	(519) 582-7220 x 263 (519) 582-7220 x 264	denise.beaton@ tim.mcdowell@
Fergus Resource Centre			**(519) 846-0941**	**(519) 846-8178**
RR 1, County Rd 18 Wellington Place Fergus N1M 2W3	Todd Leuty	Agroforestry	(519) 846-3390	todd.leuty@
Harrow Greenhouse and Processing Crops Research Centre			**(519) 738-2251**	**(519) 738-4564**
2585 County Rd 20 Harrow N0R 1G0	Gillian Ferguson Leslie Huffman Shalin Khosla	Greenhouse vegetable IPM Weed management, Horticulture Program lead Greenhouse vegetable	(519) 738-2251, x 406 (519) 738-2251, x 499 (519) 738-2251, x 405	gillian.ferguson@ leslie.huffman@ shalin.khosla@
Kemptville Resource Centre			**(613) 258-8295**	**(613) 258-8392**
Box 2004, Concession Rd Kemptville K0G 1J0	Scott Banks Dave Chapeskie Gilles Quesnel	Emerging crops Agroforestry Field crops, IPM Program lead – bilingual	(613) 258-8359 (613) 258-8302 (613) 258-8250	scott.banks@ dave.chapeskie@ gilles.quesnel@
Lindsay Resource Centre			**(705) 324-6125**	**(705) 324-1638**
322 Kent St. W Lindsay K9V 2Z9	Joel Bagg	Forage	(705) 324-5856	joel.bagg@
London Resource Centre			**(519) 873-4070**	**(519) 873-4062**
667 Exeter Rd London N6E 1L3	John Gardner	Apple specialist	(519) 873-4084	john.gardner@
New Liskeard			**(800) 461-6132**	**(705) 647-7993**
280 Armstrong St. Box 4070 New Liskeard P0J 1P0	Daniel Tasse	Agriculture and rural representative	(705) 647-2085	daniel.tasse@
Ridgetown Resource Centre			**(519) 674-1690**	**(519) 674-1564**
Agronomy Building Ridgetown College Box 400, Main St. E Ridgetown N0P 2C0	Adam Hayes Albert Tenuta Heather Griffiths (on leave Pat Dolan Anne Verhallen Elaine Roddy Janice LeBoeuf Tracey Baute	Soil management, field crops Pathologist; Field Crops Program lead IPM modelling (acting) Soil management, horticulture Vegetable crops Vegetable crops Entomology; Field Crops Program lead	(519) 674-1621 (519) 674-1617 (519) 674-1694 (519) 674-1614 (519) 674-1616 (519) 674-1699 (519) 674-1696	adam.hayes@ albert.tenuta@ pat.dolan@ anne.verhallen@ elaine.roddy@ janice.leboeuf@ tracey.baute@
Simcoe Resource Centre			**(519) 426-7120**	**(519) 428-1142**
PO Box 587 Blueline Rd & Hwy 3 Simcoe N3Y 4N5	Mike Columbus Pam Fisher Jan Schooley Kathryn Carter	New crop development Berry crop Ginseng & medicinal herbs Pome fruit IPM	(519) 426-4509 (519) 426-2238 (519) 426-4323 (519) 426-4322	mike.columbus@ pam.fisher@ jan.schooley@ kathryn.carter@
Stratford Resource Centre			**(519) 271-0280**	**(519) 273-5278**
581 Huron St. Stratford N5A 5T8	Brian Hall Peter Johnson Michael Payne Keith Reid Horst Bohner	Alternate production systems Cereals Biosolids Soil fertility Soybean	(519) 271-0083 (519) 271-8180 (519) 271-4496 (519) 271-9269 (519) 271-5858	brian.hall@ peter.johnson@ michael.payne@ keith.reid@ horst.bohner@

Field office location	Staff	Commodity or discipline	Telephone	Fax and E-mail name@omaf.gov.on.ca
Vineland - HRIO, University of Guelph			**(905) 562-4141**	**(905) 562-3413**
Box 7000, 4890 Victoria Ave. N. Vineland Station L0R 2E0	Wayne Brown Graeme Murphy	Greenhouse floriculture Greenhouse floriculture IPM	(905) 562-4141, x 179 (905) 562-4141, x 106	wayne.brown@ graeme.murphy@
Vineland Resource Centre			**(905) 562-4147**	**(905) 562-5933**
Adv. Serv. Building Box 8000 4890 Victoria Ave. North Vineland Station L0R 2E0	Ken Slingerland Donna Speranzini (on leave) Hannah Fraser Jennifer R. DeEll Neil Carter	Tender fruit and grape Nutrient Management Horticulture Crops Program lead Entomology; Horticulture Program lead Fresh Market Quality Program lead Tender fruit and grape IPM	(905) 562-1639 (905) 562-1170 (905) 562-1674 (905) 562-1693 (905) 562-3833	ken.slingerland@ donna.speranzini@ hannah.fraser@ jennifer.deell@ neil.carter@
Woodstock Resource Centre			**(519) 537-6621**	**(519) 539-5351**
Box 666, Hwy 59 N Woodstock N4S 7Z5	Christine Brown	Nutrient Management Field Crops Program lead	(519) 537-8305	christine.brown@
Guelph OMAF				**(519) 826-3567**
1 Stone Road West Guelph N1G 4Y2	Bill Ingratta Annette Anderson (on leave) Christoph Kessel Hugh Berges John Finlay Brent Kennedy Cathy Wilson Pinkney Doug McRory Kelly Ward Kristen Callow Sandra Jones Vacant Hugh Martin Jim Chaput	Director, Crop Technology Manager, Greenhouse, Agroforestry, Specialty Crops (acting) Manager, Horticulture Technology Manager, Horticulture Crops Manager, Field Crops Marketing & Communications Apiary Product development Vegetable crops On-Farm Food Safety Program lead Applied Research Coordinator Horticulture Organic Crop Production Program lead Minor Use Coordinator	(519) 826-3151 (519) 826-3286 (519) 826-3288 (519) 826-6941 (519) 826-3257 (519) 826-3150 (519) 826-3595 (519) 826-4094 (519) 826-4963 (519) 826-3289 (519) 826-4587 (519) 826-3539	bill.ingratta@ annette.anderson@ christoph.kessel@ hugh.berges@ john.finlay@ brent.kennedy@ (519) 826-3259 cathy.wilsonpinkney@ doug.mcrory@ (519) 826-4964 kelly.ward@ (519) 826-4964 kristen.callow@ (519) 826-4964 sandra.jones@ (519) 826-4964 hugh.martin@ (519) 826-4964 jim.chaput@
University of Guelph, 50 Stone Road E., Guelph N1G 2W1			**(519) 824-4120**	
Guelph Turfgrass Institute 328 Victoria Rd S, RR 2 Guelph N1H 6H8	Pam Charbonneau	Turfgrass	(519) 824-4120, x 2597	(519) 766-1704 pamela.charbonneau@
Food Science Building	Eugenia Banks	Potato	(519) 824-4120, x 2673	(519) 824-6631 eugenia.banks@
Edmund Bovey Building	Michael Celetti	Pathologist; Horticulture Crops Program lead	(519) 824-4120, x 8910	(519) 767-0755 michael.celetti@
Edmund Bovey Building	Jennifer Llewellyn	Nursery Crops	(519) 824-4120, x 2671	(519) 767-0755 jennifer.llewellyn@
Land Resource Science, Richards Building	Christoph Kessel	Nutrition; Horticulture Program lead	(519) 824-4120, x 2480	(519) 824-5730 christoph.kessel@
Crop Science Building	Mike Cowbrough	Weed Management Field Crops Program lead	(519) 824-4120, x 2580	(519) 763-8933
Crop Science Building	Ian McDonald	Applied Research Coordinator, Field Crops	(519) 824-4120, x 6707	(519) 763-8933 ian.mcdonald@
Crop Science Building	Greg Stewart	Corn Industry Program lead	(519) 824-4120, x 4865	(519) 763-8933 greg.stewart@

APPENDIX B: Ontario Ministry of Environment Pesticides Control Offices

Region and county	Pesticides officer	Address	Telephone
Central region Toronto, Halton, Peel, York, Durham	Cathy Wright	5775 Yonge St, 8th Floor Toronto, ON M2M 4J1	(416) 326-6700 1-800-810-8048 fax (416) 325-6347
West-Central Region Haldimand-Norfolk, Niagara, Hamilton-Wentworth, Dufferin, Wellington, Waterloo, Brant	Charlie Roland Suzanne Howe	Ontario Government Building 119 King St. West, 12th Floor Hamilton, ON L8P 4Y7	(905) 521-7640 1-800-668-4557 fax (905) 521-7820
Eastern Region Frontenac, Hastings, Lennox & Addington, Prince Edward, Leeds & Grenville, Prescott & Russell, Stormont/Dundas & Glengarry, Haliburton, Peterborough, Victoria, Northumberland, Renfrew, Ottawa-Carleton, Lanark, District of Nipissing (Twsps of Airy, Murchison, Dickens, Lyell and Sabine)	Roberto Sacilotto	133 Dalton Avenue P.O. Box 820 Kingston, ON K7L 4X6	(613) 549-4000 1-800-267-0974 fax (613) 548-6908
Southwestern Region Elgin, Middlesex, Oxford, Essex, Kent, Lambton, Bruce, Grey, Huron, Perth, Simcoe	Gary Roberts	733 Exeter Road, 2nd Floor London, ON N6E 1L3	(519) 873-5000 (519) 873-5048 fax (519) 873-5020
Northern Region Manitoulin, Nipissing, Parry Sound, Sudbury, Algoma East, Cochrane East, Muskoka Kenora, Rainy River, Thunder Bay, Algoma West, Cochrane West, Timmins	John Negusanti Don Mitchell	199 Larch Street, Ste 1101 Sudbury, ON P3E 5P9 435 James St., S., Ste 331 Thunder Bay, ON P7E 6S7	(705) 564-3249 fax (705) 564-4180 (807) 475-1712 fax (807) 475-1745
Standards Development Branch		Pesticides Section 40 St. Clair Avenue West, 7th Floor Toronto, ON M4V 1M2	(416) 327-5519 Fax (416) 327-2936
Environmental Assessment and Approvals Branch		Pesticides Licensing 2 St. Clair Avenue West, 12A Floor Toronto, ON M4V 1L5	(416) 314-8001 fax (416) 314-8452

APPENDIX C: Agriphones and other contacts

Agricultural Information Contact Centre

1-877- 424-1300 or (519) 826-4047
Fax (519) 826-7610
E-mail ag.info@omaf.gov.on.ca

Provides province-wide, toll-free technical and business information to commercial farms, agri-businesses and rural businesses. It is located at 1 Stone Road, West, Guelph N1G 4Y2

Government Information Centre in Guelph

Staff directories — phone 1-888-466-2372 or (519) 826-3100

Agriphone services

Phone the OMAF Tobacco Agriphone Hotline. It's updated bi-weekly during the growing season and weekly during the rest of the year.
For a recorded message, call (519) 582-1713 for local calls or toll-free at 1-800-810-0167.

Visit the OMAF web site at www.omaf.gov.on.ca to:

- view the OMAF tobacco agriphone
- subscribe online for e-mail notifications for new agriphone postings
- find information on tobacco production and other relevant topics.

Other contacts

University of Guelph
www.uoguelph.ca
Main Campus, Guelph
N1G 2W1
(519) 824-4120

Alfred College
www.alfredc.uoguelph.ca/
Alfred K0B 1A0
(613) 679-2218

Kemptville College
www.kemptvillec.uoguelph.ca
Kemptville K0G 1J0
(613) 258-8336

Ridgetown College
www.ridgetownc.on.ca
Ridgetown N0P 2C0
(519) 674-1500

Department of Plant Agriculture
www.plant.uoguelph.ca

Department of Plant Agriculture, Kettleby
1125 Woodchopper's Lane, RR 1
Kettleby, L0G 1J0
(905) 775-3783

Department of Plant Agriculture, Simcoe
Box 587 Blue Line Rd.
Simcoe, N3Y 4N5
(519) 426-7127

Department of Plant Agriculture, Vineland
Box 7000, 4890 Victoria Ave. N.
Vineland Station, L0R 2E0
(905) 562-4141

Lab Services Division
www.uoguelph.ca/labserv/

Pesticide and Trace Contaminants
PO Box 3650, 95 Stone Road West
Guelph, N1H 8J7
(519) 767-6200

Pest Diagnostic Clinic
(519) 767-6256
(For more information, see Appendix D)

Agriculture & Agri-Food Canada

Research Centres

Eastern Cereals and Oilseeds Research Centre
960 Carling Avenue
Ottawa, K1A 0C6
(613) 759-1952
http://res2agr.ca/ecorc/welcome.htm

Greenhouse and Processing Crops Research Centre
Harrow N0R 1G0
(519) 738-2251
http://res2.agr.ca/harrow/

Southern Crop Protection and Food Research Centre
1391 Sandford St.
London N5V 4T3
(519) 457-1470
http://res2.agr.ca/london/pmrc/pmrchome.html

Vineland Research Farm
4902 Victoria Ave. N.
Vineland L0R 2E0
(905) 562-4113

Delhi Research Farm
Box 186 Schafer Rd.
Delhi N4B 2W9
(519) 582-1950

Canadian Food Inspection Agency
www.cifa-acia.agr.ca

Regional Offices (Plant Protection)

Belleville
345 College Street East
Belleville K8N 5S7
(613) 969-3333

Hamilton
709 Main St. W. 101
Hamilton L8S 1A2
(905) 572-4152

London
1200 Commissioners Rd. E., Unit 19
London, N5Z 4R3
(519) 691-1300

Niagara Falls
RR 1, PO Box 7 (Mail)
Niagara on the Lake, L0S 1J0
14154 Niagara River Parkway
Unit # 5., (Street)
Niagara On the Lake
(905) 262-5331

Brantford
Federal Building,
Dalhousie & Queen St, PO Box 637
Brantford N3T 5P9
(519) 751-8157

Ottawa District
38 Auriga Drive, Unit 8
Ottawa, K2E 8A5
(613) 759-1571

Toronto Office
401 Champagne Drive, Unit 1
Downsview M3J 2C6
(416) 954-1714

Windsor
441 University Ave. W., Suite 208
Windsor N9A 5P9
(519) 252-7095

APPENDIX D: Diagnostic service

Samples for disease diagnosis, insect or weed identification, nematodes counts and Verticillium testing can be sent to the

Pest Diagnostic Clinic
Laboratory Services Division
University of Guelph
95 Stone Rd. W.,
Guelph, ON N1H 8J7
Phone: (519) 767-6256
Fax: (519) 767-6240
E-mail: pdc@lsd.uoguelph.ca

Payment must accompany samples when submitted.

Submission forms are available at *www.uoguelph.ca/pdc*.

Procedures	Price/sample
Plant diseases	
Diagnosis not requiring plating	$25
Diagnosis requiring plating	$40
Turf diagnosis	$50
Bacterial identification using Biolog®	$95
Detection of virus using transmission electron microscopy	$85
Detection of virus using ELISA (turn around time 5 working days, bulk rates available)	$60
Weed identification	$40
Insects	
Basic identification	$25
Identification requiring dissection and/or extensive keys	$40
Nematode and Verticillium counts	
Nematodes extracted from soil (Bearman Pan Method, 7 or 8 days turn around time)	$25
Soybean cyst nematode (3 or 4 days turn around) & egg count	$35
Nematodes extracted from roots (15 days turn around)	$60
Verticillium count	$60

Charges will be applied to each sample submitted. Payment: Please make cheque payable to the University of Guelph.VISA and Mastercard are also accepted. Please do not mail cash.

How to sample for nematodes

Soil

When to sample

Take soil and root samples at any time when the soil is not frozen. In Ontario, nematode soil population levels are generally highest in May–June and again in September–October.

How to sample soil

Take samples using a soil-sampling tube, trowel or narrow-bladed shovel. Sample soil to a depth of 20–25 cm (8–10 in.). If the soil is bare, remove the top 2 cm (1 in.) before sampling. Combine 10 or more subsamples in a clean pail or plastic bag. Mix them well. Take 1/2–1 L (1 pt–1 qt) from this to create a sample. No one sample should represent more than 2.5 ha (6.25 ac). Mix the subsamples in a clean pail or plastic bag.

Sampling pattern

If living crop plants are present in the sample area, take samples within the row and from the area of the feeder root zone (with trees this is the drip line).

Number of subsamples

The number of subsamples is based on the total area sampled:

- for 500 m^2 (5,400 sq ft) take 10 subsamples
- for 500 m^2–0.5 ha (5,400 sq ft–1.25 ac) take 25
- for 0.5 ha–2.5 ha (1.25–6.25 ac) take 50

Roots

From small plants, take the entire root system plus adhering soil. For large plants, dig 10–20 g (1/2–1 oz) fresh weight from the feeder root zone and submit it.

Problem areas

Take soil and root samples from the margins of the problem area where the plants are still living. If possible, also take soil and root samples from both problem and healthy areas in the same field.

Sample handling

Soil samples

Place in plastic bags as soon as possible after collecting.

Root samples
Place in plastic bags and cover with moist soil from the sample area.

Storage
Store samples at 5–10 C (40–50 F) and do not expose them to direct sunlight or extreme heat or cold (freezing). Only living nematodes can be counted. Accurate counts depend on proper handling of samples.

Submitting plants for disease diagnosis or identification

Sample submission forms
Forms can be obtained from an OMAF office. Carefully fill in all of the categories on the form. In the space provided draw the most obvious symptom and the pattern of the disease in the field. It is important to include the cropping history of the area for the past 3 years and this year's pesticide use records.

Choose a complete, representative sample showing early symptoms. Submit as much of the plant as is practical, including the root system. Or submit several plants showing a range of symptoms. For turfgrass, submit a 10–15 cm square piece of turf, including thatch and at least 5 cm of soil. Take the sample from the outside edge of a ring or patch and include unhealthy and healthy turf and the interface in between. If symptoms are general, collect the sample from an area where they are of intermediate severity.

Completely dead material is usually inadequate for diagnosis. Include at least a 20–25 cm sample of the top portion of the stem with lateral buds, leaves, flowers or fruits in identifiable condition. Wrap plants in newspaper and put in a plastic bag. Tie the root system off in a separate plastic bag so that it does not dry out and the soil does not contaminate the leaves.

Do not add moisture, as this encourages decay in transit. Cushion specimens and pack them in a sturdy box to avoid damage during shipping.

Avoid leaving specimens to bake or freeze in a vehicle or in a location where they can deteriorate.

Delivery
Delivery to the Pest Diagnostic Clinic should be made as soon as possible by first class mail or by courier at the beginning of the week.

Submitting insect specimens for identification

Collecting samples
Place dead, hard-bodied insects and spiders in vials or boxes and cushion them with tissues or cotton. Place soft-bodied insects and caterpillars in vials containing alcohol. Do not use water as they will rot. Do not tape the insects to paper or send them loose in an envelope.

Place live insects in a container with enough plant "food" to support them during transit. Be sure to write "live" on the outside of the container.

APPENDIX E: Crop Insurance

The Canada-Ontario Crop Insurance Program is publicly funded by the Government of Canada and the Province of Ontario and delivered by AGRICORP. The federal and provincial governments each contribute 25% of the premium cost and 50% of the administrative costs. These contributions enable an Ontario grower to buy insurance coverage at a substantially reduced cost.

The grower's payment is considered an operating expense for income tax purposes. Crop insurance offers protection against a broad range of production hazards, including excessive rain, hail, excessive drought, freeze, frost, excessive wind and certain insects and diseases.

For further information, please call AGRICORP's Customer Action Centre at 1-888-AGRI-999 (1-888-247-4999)
AGRICORP
1 Stone Road West
Box 3660, Station Central
Guelph, Ontario
N1H 8M4
(519) 826-3276
Fax: (519) 826-4118
www.agricorp.com

Ontario Crops Covered by Crop Insurance Plan

Fruit crops		
Apples (fruit and/or trees)	Cherries, sweet and sour	Grapes (fruit and/or vines)
Peaches	Pears	Plums
Strawberries		
Vegetable crops		
Asparagus	Green beans and wax beans (processing)	Beets (processing)
Broccoli	Cabbage	Carrots (fresh)
Carrots (processing)	Cauliflower	Celery
Cucumbers (processing)	Lettuce	Lima beans (processing)
Parsnips	Peas (processing)	Peppers
Potatoes	Rutabagas	Seed onions
Set onions	Spanish onions	Butternut squash (processing)
Sweet corn (fresh)	Sweet corn (processing)	Tomatoes (processing)
Tomatoes (fresh)		
General crops		
Coloured beans	White beans	Canola
Corn (grain and silage)	Seed corn	Forage
New forage seeding	Honey	Peanuts
Popping corn	Soybeans	Spring grain
Sugar Beets	Sunflower	Red spring wheat
Wheat, winter	Industrial hemp	
Tobacco		
Black	Flue-cured	

APPENDIX F. The Metric System

Metric Units

Linear Measures (length)

10 millimetres (mm) = 1 centimetre (cm)
100 centimetres (cm) = 1 metre (m)
1,000 metres = 1 kilometre (km)

Square Measures (area)

100 m x 100 m = 10,000 m^2 = 1 hectare (ha)
100 ha = 1 square kilometre (km^2)

Cubic Measures (volume)

Dry Measure

1,000 cubic millimetres (mm^3)=1 cubic centimetre (cm^3)
1,000,000 cm^3 = 1 cubic metre (m^3)

Liquid Measure

1,000 millilitres (mL) = 1 litre (L)
100 L = 1 hectolitre (hL)

Weight-Volume Equivalents (for water)

(1.00 kg) 1,000 grams = 1 litre (1.00 L)
(0.50 kg) 500 grams = 500 mL (0.50 L)
(0.10 kg) 100 grams = 100 mL (0.10 L)
(0.01 kg) 10 grams = 10 mL (0.01 L)
(0.001 kg) 1 gram = 1 mL (0.001 L)

Weight Measures

1,000 milligrams (mg) = 1 gram (g)
1,000 grams = 1 kilogram (kg)
1,000 kilograms = 1 tonne (t)
1 mg/kg = 1 part per million (ppm)

Dry-Liquid Equivalents

1 cm^3 = 1 mL
1 m^3 = 1,000 L

Calculating parts per million (ppm)

1 ppm = 1 g active ingredient per 1,000 L water

Handy metric conversion factor

litres per hectare x 0.4 = litres per acre
kilograms per hectare x 0.4 = kilograms per acre

Application Rate Conversions

Metric to Imperial (approximate)

litres per hectare x 0.09 =gallons per acre
litres per hectare x 0.36 =quarts per acre
litres per hectare x 0.71 =pints per acre
millilitres per hectare x 0.015 =fluid ounces per acre
grams per hectare x 0.015 =ounces per acre
kilograms per hectare x 0.89 =pounds per acre
tonnes per hectare x 0.45 =tons per acre

Imperial to Metric (approximate)

gallons per acre x 11.23 = litres per hectare (L/ha)
quarts per acre x 2.8 = litres per hectare (L/ha)
pints per acre x 1.4 = litres per hectare (L/ha)
fluid ounces per acre x 70 = millilitres per hectare (mL/ha)
tons per acre x 2.24 = tonnes per hectare (t/ha)
pounds per acre x 1.12 = kilograms per hectare (kg/ha)
ounces per acre x 70 = grams per hectare (g/ha)

Liquid Equivalents

litres/hectare	*approx. gallons/acre*
50	= 5
100	= 10
150	= 15
200	= 20
250	= 25
300	= 30

Dry Weight Equivalents

grams or kilograms/hectare	*ounces or pounds/acre*
100 grams =	1 1/2 ounces
200 grams =	3 ounces
300 grams =	4 1/4 ounces
500 grams =	7 ounces
700 grams =	10 ounces
1.1 kilograms =	1 pound
1.5 kilograms =	1 1/4 pounds
2.0 kilograms =	1 3/4 pounds
2.5 kilograms =	2 1/4 pounds
3.25 kilograms =	3 pounds
4.0 kilograms =	3 1/2 pounds
5.0 kilograms =	4 1/2 pounds
6.0 kilograms =	5 1/4 pounds
7.5 kilograms =	6 3/4 pounds
9.0 kilograms =	8 pounds
11.0 kilograms =	10 pounds
13.0 kilograms =	11 1/2 pounds
15.0 kilograms =	13 1/2 pounds

Metric Conversions

5 mL = 1 tsp
15 mL = 1 tbsp
28.5 mL = 1 fl. oz

Conversion Tables — Metric to Imperial (approximate)

Length

1 millimetre (mm)= 0.04 inch
1 centimetre (cm)= 0.40 inch
1 metre (m)= 39.40 inches
1 metre (m)= 3.28 feet
1 metre (m)= 1.09 yards
1 kilometre (km)= 0.62 mile

Area

1 square centimetre (cm^2)= 0.16 square inch
1 square metre (m^2)= 10.77 square feet
1 square metre (m^2)= 1.20 square yards
1 kilometre (km^2)= 0.39 square mile
1 hectare (ha)= 107,636 square feet
1 hectare (ha)= 2.5 acres

Volume (dry)

1 cubic centimetre (cm^3)= 0.061 cubic inch
1 cubic metre (m^3)= 1.31 cubic yards
1 cubic metre (m^3)= 35.31 cubic feet
1,000 cubic metres (m^3)= 0.81 acre-foot
1 hectolitre (hL)= 2.8 bushels

Volume (liquid)

1 millimetre (mL)= 0.035 fluid ounce
1 litre (L)= 1.76 pints
1 litre (L)= 0.88 quart
1 litre (L)= 0.22 gallon (Imp.)
1 litre (L)= 0.26 gallon (U.S.)

Weight

1 gram (g)= 0.035 ounce
1 kilogram (kg)= 2.21 pounds
1 tonne (t)= 1.10 short tons
1 tonne (t)= 2,205 pounds

Pressure

1 kilopascal (kPa)= 0.15 pounds/in^2

Speed

1 metre per second= 3.28 feet per second
1 metre per second= 2.24 miles per hour
1 kilometre per hour= 0.62 mile per hour

Temperature

°F= (°C X 9/5) + 32

Imperial to Metric (approximate)

Length

1 inch =2.54 cm
1 foot = 0.30 m
1 yard = 0.91 m
1 mile = 1.61 km

Area

1 square foot = 0.09 m^2
1 square yard = 0.84 m^2
1 acre = 0.40 ha

Volume (dry)

1 cubic yard =0.76 m^3
1 bushel = 36.37 L

Volume (liquid)

1 fluid ounce (Imp.) =28.41 mL
1 pint (Imp.) = 0.57 L
1 gallon (Imp.) = 4.55 L
1 gallon (U.S.) = 3.79 L

Weight

1 ounce = 28.35 g
1 pound = 453.6 g
1 ton =0.91 tonne

Pressure

1 pound per square inch = 6.90 kPa

Temperature

°C = (°F – 32) X 5/9

Abbreviations

ai - active ingredient
AP- agricultural powder
cm - centimetre
cm^2 - square centimetre
DG - dispersible granular
DP - dispersible powder
E - emulsifiable
EC - emulsifiable concentrate
e.g. - for example
F - flowable
g - gram
Gr - granules, granular
ha - hectare
kg - kilogram
km - kilometre
km/h - kilometres per hour
kPa - kilopascal
L - litre
m - metre
m^2 - square metre
mL - millilitre
mm - millimetre
m/s - metres per second
SC - sprayable concentrate
SP - soluble powder
t - tonne
W - wettable (powder)
WDG - water dispersible granular
WP - wettable powder
% - per cent (by weight)

Kiln Record

Harvesting Information

Harvesting date:
Weather conditions:
Field harvested: (location, variety, stalk position, etc.)
Other comments:

Curing Information

Kiln started: (Date) _____ (Time) _____ (a.m. / p.m.)

Date	Time	Interval (degrees, # hours)	Temperature		Air intake	Other comments
			Dry bulb	Wet bulb		

Kiln shut off: (Date)_____ Grading information:

(Time)_____(a.m. / p.m.)

Date of kiln unloading:

Kiln Record

Harvesting Information

Harvesting date:
Weather conditions:
Field harvested: **(location, variety,** **stalk position, etc.)**
Other comments:

Curing Information

Kiln started: (Date) _____ **(Time)** _____ **(a.m. / p.m.)**

Date	Time	Interval (degrees, # hours)	Temperature		Air intake	Other comments
			Dry bulb	Wet bulb		

Kiln shut off: **(Date)**_____ **Grading information:**

(Time)_____**(a.m. / p.m.)**

Date of kiln unloading:

Kiln Record

Harvesting Information

Harvesting date:
Weather conditions:
Field harvested: (location, variety, stalk position, etc.)
Other comments:

Curing Information

Kiln started: (Date) _____ (Time) _____ (a.m. / p.m.)

Date	Time	Interval (degrees, # hours)	Temperature		Air intake	Other comments
			Dry bulb	Wet bulb		

Kiln shut off: (Date)_____ Grading information:

(Time)_____(a.m. / p.m.)

Date of kiln unloading:

Emergency and First-Aid Procedures for Pesticide Poisoning

For a major spill, a theft or a fire involving a pesticide call the Ministry of the Environment at **1-800-268-6060.**

For pesticide poisonings and pesticide injuries call the Poison Information Centre:

Toronto	1-800-268-9017
Ottawa (Bilingual)	1-800-267-1373
Hearing Assistance (TTY)	1-877-750-2233

PREVENT ACCIDENTS

- **Read the label.** Follow all the precautions the label recommends. Read the First Aid section of the label BEFORE you begin to handle any pesticide.
- **Make sure that someone knows** what pesticides you are working with and where you are.
- **Keep a file of labels and product Material Safety Data Sheets (MSDS) for the pesticides you use.** Make sure everyone knows where to find this in case of an emergency.
- **Post emergency numbers near all telephones.**
- **Keep clean water, paper towels, extra gloves and clean coveralls close by** in case you spill pesticide on yourself.

If someone has been working with pesticides and you see any possible symptoms of pesticide poisoning or injury, take emergency action immediately.

IF AN ACCIDENT OR POISONING HAPPENS

- Protect yourself from injury first.
- Stop the exposure to the pesticide. Move the victim away from the contaminated area.
- Check the 4 basic facts — identify the pesticide, the quantity, the route of entry and time of exposure.
- Call an ambulance or the Poison Information Centre.
- Start first aid. This is not a substitute for professional medical help.
- **Provide the label, MSDS sheet or container to emergency personnel** at the scene — or take it with you to the hospital. Do not transport pesticide containers in the passenger compartment of the vehicle.

Cette publication hautement spécialisée n'est disponible qu'en anglais en vertu du réglement 411/97, qui en exempte l'application de la *Loi sur les services en français*. Pour obtenir de l'aide en français, veuillez communiquer avec le ministère de l'Agriculture et de l'Alimentation au numéro 1 877 424-1300.

FIRST AID

If a pesticide comes in contact with skin:

- remove all contaminated clothing; wash skin thoroughly with lots of soap and warm water
- dry skin well and cover with clean clothing or other clean material.

If pesticide comes in contact with eyes:

- hold eyelids open wash the eyes with clean running water for 15 minutes or more.

If pesticide was inhaled:

- move the victim to fresh air and loosen tight clothing
- give artificial respiration if the victim is not breathing.

Do not breathe in the exhaled air from the victim — you could also be poisoned.

If a pesticide was swallowed:

- **call the Poison Information Centre IMMEDIATELY.**

Emergency numbers are listed at the front of each Bell telephone directory.

For information, or to obtain copies of this or any other ministry publication please:
call 1-888-466-2372 from within Ontario, (519) 826-3700 from outside the province or OMAF's TTY line at (519) 826-7402 for the hearing impaired, email your request to *products@omaf.gov.on.ca*, or visit OMAF's Web site at *www.omaf.gov.on.ca*.

A complete list of all OMAF products and services, and order forms, are available on the Web site. Orders can be faxed to (519) 826-3633 or mailed to Government Information Centre, OMAF, 1 Stone Road West, Guelph, Ontario N1G 4Y2.

Published by the Ministry of Agriculture and Food
© Queen's Printer for Ontario, 2003
Toronto, Canada

ISSN 1492-5397 RV 06-03-2.5M

www.omaf.gov.on.ca